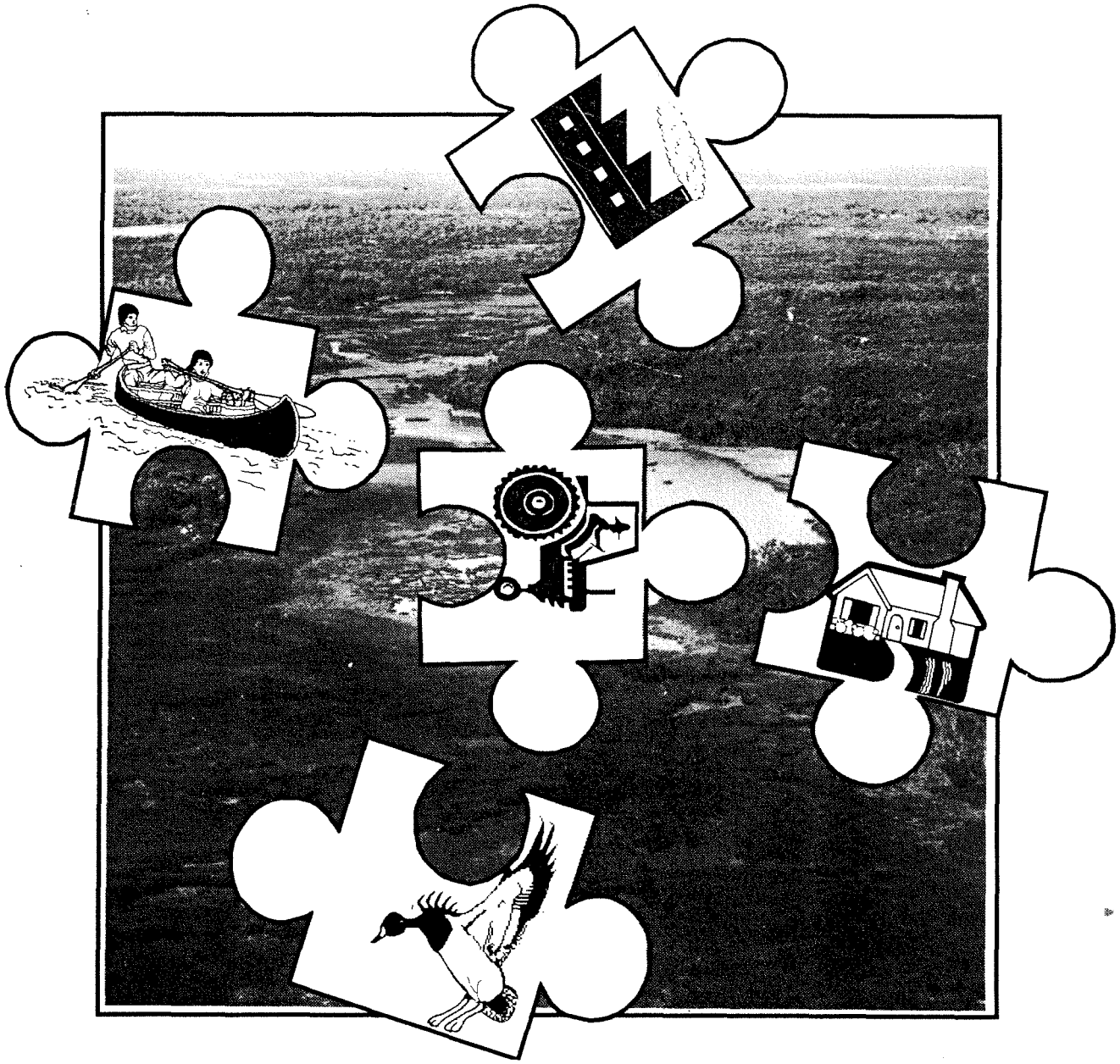
Wetlands in Crisis

What can Local Government Do?

Conference Papers
15 June 1988



A contribution to The State Conservation Strategy

Environmental Protection Authority
Perth, Western Australia

Bulletin 372 July 1989

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Planning and Management for Wetland Conservation
Conference 15 June 1988

Jointly organised by Murdoch University,
School of Biological and Environmental Sciences
and the Environmental Protection Authority

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PREFACE

The wetlands of the Swan Coastal Plain are a valuable part of our natural environment and possess considerable social, recreational and conservation value.

Urban development and agricultural activities are placing great stress on wetlands. The environmental quality of many wetlands is rapidly deteriorating.

This conference brings together various groups concerned with wetland management and research. Special emphasis is placed on the role of local government authorities who are responsible for managing many wetlands and for local planning and management decisions.

The conference papers and the problems and management solutions identified by the participants during the conference sessions provided a major input to a booklet on Planning and Management for Wetland Conservation. The booklet is being produced by the Environmental Protection Authority to provide practical guidelines for local government authorities and others directly involved in urban planning and wetland management in Western Australia. Users will include planners, engineers, landscape architects and land managers. It is expected to be available late 1989.

The organisers wish to thank those who contributed papers to this well attended and successful conference.

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* Abstract only

ADDRESS BY THE MINISTER FOR ENVIRONMENT HON BARRY HODGE TO THE CONFERENCE "WETLANDS IN CRISIS - WHAT CAN LOCAL GOVERNMENT DO"

Thank you Jenny Davis and Frank Murray for organising this workshop. It is clear from the large attendance that the topic "Wetlands in Crisis" is of great interest to many people.

The Government recognises that wetlands on the Swan Coastal Plain and elsewhere suffer from a variety of problems. These problems include:

. the loss of wetlands by filling and draining;

. nutrient enrichment and nuisance algal growth;

. water level changes from use of groundwater or inflow of urban runoff; and

. damage to wildlife populations and mosquito and midge plagues.

These problems basically arise because there is a conflict amongst various interests competing for the use of land and water resources, and for the environment itself. This problem does not belong to any specific group but to everyone, and local government is a major decision-making and management force in this area.

Publication and endorsement of the State Conservation Strategy emphasises this Government's concern to maintain healthy environments, and to provide for a high quality of life. A variety of initiatives under way show that this Government is prepared to act and to commit resources towards rehabilitation and ongoing management of the environment. These initiatives include:

. revision of the Environmental Protection Act;

. emphasis by the Water Authority on broadly based management of water resources, that is management which takes the environment into account;

. Cabinet's endorsement of the concept of integrated catchment management and the formation of the Catchment Management Policy Group;

. establishment of the CALM Act which has led to a greater focus of attention to management of public lands with high value;

. support for the establishment of wetland regional parks; and

. support by various Government Agencies to research and management investigations of wetlands and their processes.

A vital element of all of the above is the communication of the results to people whose decisions influence the quality of wetland environments. I congratulate all of you here today for your interest in this matter and trust that greater understanding and cooperation will lead to significant improvements in the management of Perth's wetlands.

Funding of wetland investigations in the current financial climate does present problems, but I am most encouraged to see active participation by local government authorities in the support of relevant research. For

example, a major study orientated towards nuisance midge control is currently under way and involves the participation of Jenny Davis's group here at Murdoch, six local authorities, CALM, SPC and EPA.

Other jointly funded investigations are either proposed or under way, and I am enthusiastic about the willingness of both State and Local Government Agencies to collaborate in this manner.

Active management of wetlands is also occurring, and adding to the knowledge essential for good management. Such management initiatives include

. preparation of CALM management plans for Lake Forestdale, Yanchep National Park and Herdsman Lake;

. preparation of management plans for Lake Monger and the Freeway interchange lakes by Perth City Council and Main Roads Department;

. management plans of North Lake and Lake Yangebup prepared by Murdoch students under Frank Murray's guidance and with financial support from a number of agencies; and

. management initiatives for Mary Carroll Park Lake and Marmion Lake by the relevant local authorities.

This seminar follows a similar one relating to the environment of the Swan Coastal Plain. That particular conference held at the Technology Park near Curtin University related to the development of agriculture as it may affect other values, particularly environmental quality on the Plain.

I understand that seminar was also well attended, and was opened by my colleague Julian Grill, the Minister for Agriculture. He demonstrated that there is a real concern by the community to ensure that those elements which are attractive in the Swan Coastal Plain are conserved and appropriately managed.

It is for this reason that the Government has recently said that should the Environmental Protection Authority find the 'Dawesville Cut', and related catchment management of the Peel and Harvey Estuarine System environmentally acceptable, the Government would be happy to proceed with that undertaking.

This demonstrates our commitment towards the environment which is a major aspect in the maintenance of quality of life.

I understand also, that the same general theme will be further discussed so that rational planning can occur, through a seminar in October on the groundwater resources of the Swan Coastal Plain.

So in this year, we can see that the Government has made a substantial commitment to enable the community to understand and assist in providing ideas for the management of this important area. In summary:

. a seminar on agriculture and environment;

. a seminar, as of today, on the wetlands of the Swan Coastal Plain; and

. and coming up, a consideration of the utilisation of groundwater;

All of this activity adds up to a large commitment of both resources, money, and effort by a lot of agencies and individuals. Better knowledge of wetland processes is essential to improve our management of these vitally important habitats. I see this conference as being an important step towards the integration of the available knowledge, and in the exposure of the deficiencies in our knowledge.

Wetlands do have problems as the title of this conference suggests and it is vital that the problems are owned by the whole community.

I have pleasure in declaring this conference open.

THE VALUE OF WETLANDS

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ABSTRACT

Wetlands are lakes, swamps, tidal marshes and mudflats, estuaries, rivers and streams. The people of Perth are fortunate in having many wetlands nearby on the Swan Coastal Plain, despite the fact that 80% have been lost since European settlement due to filling and draining. However, increasing public appreciation of our wetlands can be expected to generate resistance to any further erosion of this natural asset.

Wetlands support an abundance of wildlife of which waterbirds are certainly the most spectacular. Over 80 species live on the Swan Coastal Plain wetlands for all or part of the year. The greatest numbers are seen during the summer when inland lakes become dry and the local population is further swollen with the arrival of transequatorial migratory birds. Many other flightless vertebrates also depend on wetland habitats.

Much of the wildlife seen at the wetlands results from a largely unseen mass of life beneath the water's surface. Small aquatic plants and animals comprise an intricate food web which sustains many waterbirds and other high order consumers. Not surprisingly, a number of rare and endangered species depend heavily on our remaining wetlands.

Individual wetlands vary enormously in their characteristics, but all are components of a total life support system. Waterbirds, for example, have very different feeding and breeding requirements, and very few of our wetlands provide for all their needs at the one time or throughout the year. Thus there is an ever-changing pattern of wetland use by waterbirds and it is misleading to consider some wetlands important and others not.

A range of wetland habitats is also needed to maintain genetic diversity within a species, so essential to its survival.

Australia has made specific commitments to conserve wetlands under the Ramsar Convention and the Japan Australia Migratory Bird Agreement. It is encumbent on us to give substance to these commitments. Wetlands are considered a valuable resource for education and recreation as well a wildlife.

The high commercial value of wetlands is reflected in real estate prices for views across water. Their value to the fishing industry is also considerable since estuarine shallows function as fish nurseries. For the tourist industry too, wetlands have great potential, judged from overseas experience.

The wealth we have inherited has been gained at considerable cost to the environment. If we now consider ourselves custodians of the wetlands, future generations will have something of greater value to inherit. To this end we must be prepared to make major commitments with a timescale extending well beyond the immediate future.

THE WETLANDS

Wetlands are lakes, swamps, tidal marshes and mudflats, estuaries and rivers and their tributaries. They have waterlogged soils for all or part of the year and may be fresh or saline. Apart from any visible surface water, the freshwater wetlands of the South-West region of Australia are most easily recognised by their natural vegetation of paperbark trees, flooded gums and reeds. Samphire and other small salt-tolerant plants are typical of the saline marshlands and estuarine foreshores. Numerous animals have a particular affinity for wetlands and may in fact, depend on them for their survival. Wetlands therefore, have distinctive forms of plant and animal life which are found nowhere else.

Despite living in one of the world's driest continents, the people of Perth are fortunate in having adequate rainfall and ready access to many wetlands throughout the Swan Coastal Plain. This extends from the Moore River in the north to Bunbury, and east-west from the Darling Scarp to the Indian Ocean. These wetlands have not always been regarded with favour as many have been drained or filled for a variety of reasons including agricultural development, sanitary landfill, industrial waste disposal, stormwater sumps, road construction and urban development. As a consequence, about 80 per cent of the wetlands existing at the time of European settlement have been lost forever.

Continuation of these destructive activities is meeting increasing resistance from many sections of society because attitudes have changed remarkably over the past fifteen years or so. In the current climate of opinion, any further erosion of the wetlands will undoubtedly require heavy justification on the basis that the greater community good resulting from doing so, will far exceed the value of the asset lost. This obviously requires a value judgement and it is the purpose of this paper to assist those who have to make such judgements by presenting the many viewpoints from which society considers wetlands to be valuable.

NATURAL HABITAT

Wetlands support a very specialised type of vegetation which provide an ideal habitat for a diverse and abundant array of animal life. Many plants and animals depend totally on wetlands such that any threat to the integrity of wetland habitats jeopardises their very existence. In addition, native animals of the woodlands depend on permanent water to survive the summer and especially in times of drought.

Undoubtedly, the most spectacular inhabitants of the wetlands are the many and varied waterbirds which use them. Swans, ducks, heron and egrets are familiar sights while the more elusive rails, crakes and bittern may be found by only the more persistent observer. Over eighty species of waterbirds have been recorded on the wetlands of the Swan Coastal Plain. Not all are found at all the wetlands throughout the year and, indeed, regular seasonal migrations occur in response to the filling and drying of water bodies inland and along the coastal plain.

Many thousands of waterbirds abandon the coastal wetlands soon after the opening autumn rains. They migrate to seasonal wetlands in the agricultural and pastoral regions for winter feeding and breeding. As the inland waterbodies dry out during the summer, the birds return to the more permanent wetlands of coastal districts. Of course, many coastal wetlands also become dry in the warmer months, so that increasing numbers of waterbirds concentrate on permanent wetlands until the advent of substantial autumn rainfall.

The Swan Coastal wetlands are also vital for many transequatorial migratory birds. These incredible little waders breed in the summer of the northern hemisphere in such remote places as Siberia and Manchuria. In August, they fly to Australia to feed on tidal mudflats and shallow lakes. Large numbers can be seen at various places on the shores of the Swan and Peel/Harvey estuaries and on a number of coastal lakes of which Thomsons and Forrestdale are the most outstanding.

Other vertebrates which inhabit the wetlands or live close by include the Short-nosed Bandicoot, Long-necked Tortoise, Western Tiger Snake, Dugite, at least eight species of frogs and some native fish. Although not as readily seen as the waterbirds, these animals add to the biological interest of such areas and are part of the ecological balance of nature. Frogs are a vital food supply for many birds and reptiles and without them the life of the wetlands would be impoverished.

LIFE IN THE WATER

Much of the abundant life seen at wetlands results from an even more abundant and complex mass of life beneath the water's surface. This is often difficult to appreciate because it is largely unseen. Powered by energy from the sun, reeds, submerged plants and numerous forms of algae and plant plankton comprise the basis for this life. On these, feed microscopic animal life and water snails. These in turn, provide food for a host of aquatic predators such as Dragonfly and Damselfly nymphs, water mites and bugs such as Water Boatmen and Backswimmers. They also feed on animals which are busy consuming the dead remains of plants and animals in the water. These consumers of dead material include shrimps and other crustaceans, the larvae of beetles, Mayfly and Caddisfly, mudworms and midge larvae.

In all, more than eighty different species of aquatic animals (macroinvertebrates) are known to live in the freshwater wetlands of the Swan Coastal Plain. They are involved in an intricate pattern of eating and being eaten which is best described as a food web rather than a food chain. In a healthy wetland, there is a balance between the components of the system, but this can easily be upset when external factors cause the supply of any component to exceed the rate at which it is consumed.

The driving force for aquatic life is the energy of the sun. Increasing light penetration and water temperature during the spring and summer triggers a population explosion in the water which dramatically increases the food supply for waterbirds in particular. It is for this reason that migratory waders from the northern hemisphere arrive here in spring, and that local waterbirds choose to hatch and rear their young at this time. During the closing stages of drying out in some lakes the water virtually becomes bird soup until the aquatic food web collapses and the waterbirds depart.

Apart from the added beauty they bestow, the trees, shrubs, reeds and grasses in and around wetlands are an integral part of the total life-support system for many of the animals found there. Some waterbirds roost and build nests in the trees while others conveniently use them as places to dry out. Protected nesting sites are also provided by tall shrubs and reeds which become surrounded with rising water in the winter. Even old logs protruding from the water's surface become resting sites for tortoises.

RARE PLANTS AND ANIMALS

With so many of the wetlands now lost, it is not surprising that a number of rare and endangered species depend heavily on what little is left. The most outstanding example is the Western Swamp Tortoise, more commonly known as the Short-necked Tortoise. From a total population of 200 in 1953, this inoffensive little animal has declined to less than 50 at present. The few in the wild are confined to two small swamps not far north of Perth.

The friendly small marsupial that delights so many visitors to Rottnest Island, the Quokka, was once common near our coastal wetlands, but its habitat range is now restricted to a few forest swamps. The Australian Water Rat too was once plentiful throughout the South West but is now rarely seen. It was hunted almost to extinction for its fur early this century and much of its natural habitat has since been lost or severely depleted.

The Freckled Duck is one of the world's most endangered waterbirds because it has been deprived of its fairly restricted preferred habitat by wetland degradation. Some are still found in small numbers in our South West, and on some of the inland waterways of south-eastern parts of the continent. In the plant kingdom, the Swamp Lily is now comparatively rare on the Swan Coastal Plain.

Obviously, the wetlands have immense value for the survival of such animals and plants which have a very restricted range of habitat tolerance.

WORKING WETLANDS

Individual wetlands are only components of a total life-support system. To understand why this is so, it is useful to consider how different waterbirds use them to satisfy their various needs. All waterbirds need places where there is a ready supply of food, and places for resting, preening, roosting and moulting which are safe from predators and other disturbances. Most importantly, they must have safe nesting sites and places to rear their young which are sheltered and can sustain their increasing demand for food.

The food of waterbirds and their means of getting it are almost as varied as the birds themselves. Swan have long necks and can browse on the bed of a lake some distance from the shore. Bobbing ducks have shorter necks and are restricted to bottom feeding, closer inshore.

Shallow waters towards the shoreline usually yield the most abundant supply of food. Here large numbers of birds sift through the water for food or probe the sand and silt with long bills well adapted to this method of feeding. Other waterbirds with short bills pick up food right at the water's edge. The bills of some ducks are beautifully designed for skimming the water's surface for emerging insects such as midges. Beyond the reach of the swans, the main body of a lake is accessible to diving ducks which feed on midge larvae and other creatures of the sediments.

The nesting habits of waterbirds can also be extremely varied and sometimes quite extraordinary when we consider the need to keep eggs warm during incubation in such a cold damp environment. Some build the base of the nest on the bed of the wetland and build it up just above the water line. Violent fluctuations in water level obviously spell disaster for many of these. Some birds, which lay eggs in August and have long incubation periods, build up their nests to a height which anticipates the continued rise in water level. Other waterbirds overcome this problem by building floating nests from reeds such as the Jointed Twig Rush which has air cells giving them buoyancy.

Shrubby plants out in the water are good nesting sites for many waterbirds due to the stability and cover they afford. A number of waterbirds nest in tall trees which may be located at a wetland or some distance from it. Others make nests on the ground in sheltered places nearby, although these are often not successful as they may be vulnerable to introduced predators.

COMPLEMENTARY FUNCTIONS

Not all the wetlands of our coastal plain provide for all the needs of waterbirds at the one time, in fact very few do. In a single day, birds can move rapidly from one wetland to another in pursuit of food. Even during the breeding season, some birds rear their young in nests far removed from where they feed. Booragoon Lake in the City of Melville, for example, is a favoured nesting site for Darters and four species of Cormorants which feed in the Swan and Canning Rivers and their wetlands. Other birds move their flightless offspring from safe nesting sites which dry out to nearby wetlands which are more permanent. Some quite small wetlands are known to be favoured breeding sites for certain waterbirds, but are totally abandoned in the summer. The seasonal drying of wetlands of source, provides quite marked movements of waterbirds both within the State and internationally. Throughout the year then, different types of wetlands perform different life-sustaining functions for waterbirds.

Probably one of the most noticeable features of our coastal wetlands is the great variation in the type of habitat they provide. They may be deep, shallow, permanent, seasonal, covered in reed beds, have open shorelines or carry dense vegetation, and be saline or fresh, large or small. It seems certain, however, that all are used by waterbirds as an essential life-sustaining resource for part of the year at least. We may in fact, regard all the individual wetlands of the Swan Coastal Plain as components of one whole regional wetland in which each of the individual wetland segments are important because without them, the functions of the whole are compromised.

It is therefore misleading to think that some wetlands are important and others are not, and any attempt to promote such a concept should be resisted strongly. They are all important from many viewpoints, not the least of which is the fact that so few are left and so many are degraded. Even those that are no longer pristine, can be rehabilitated provided the community has the will to do so.

DROUGHT REFUGE

Any assessment on the extent to which wildlife uses various wetlands, and to what purpose, can be misleading if no account is taken of abnormal seasonal rainfall patterns. The normal weather cycle provides for dry summers and rain over the whole South West and into the agricultural districts in winter. A normal pattern of waterbird migration is associated with this and seasonal patterns of the extent to which individual wetlands are used by birds can be described. Unfortunately, occasional and sometimes protracted droughts have become a force to be reckoned with. The coastal wetlands are generally less affected by such events since rainfall here is more reliable. As a drought refuge for waterbirds, then the coastal wetlands are immensely valuable, especially those which are permanent even in dry years.

Land clearing in the agricultural areas has, over the years, severely degraded many waterbird habitats inland due to rising salt. Rivers and streams which feed wetlands have become saline, seriously limiting their value for waterbirds. These events given added importance to the coastal wetlands because they are relatively fresh.

ADAPTATION TO THE ENVIRONMENT

The great variation in the appearance and functioning of our plants and animals is due to their adaptations to particular types of environments. However, no two individuals are exactly the same and this allows each species to have some tolerance for a range of environmental conditions. Thus we have genetic variation within a species which is essential to its survival. Those individuals best adapted to any particular set of environmental conditions will survive the best while others tend to perish.

The degree of genetic variation within a species will be reflected in the range of habitats it can adapt to. The converse is also true in that the range of habitats occupied by any particular plant or animal can be attributed to the amount of genetic variation within the species, at least in part.

As we know, the wetlands of the Swan Coastal Plain offer a great range of environments for the plants and animals which they support. The preservation of all these wetlands would therefore be essential if we are to maintain the genetic diversity of the wetland species, so essential to their survival. In the context of a changing climate due to the "greenhouse effect", their collective importance is magnified.

INTERNATIONAL OBLIGATIONS

Many nations throughout the world recognise that wetlands constitute a resource of great economic, cultural, scientific and recreational value. Furthermore, they consider them an international resource because so many waterbirds cross national boundaries in their seasonal migrations. It is not surprising then that international agreements have been developed to preserve at least the most significant of the world's wetlands, especially those used by migratory birds.

The first agreement, made in 1974, was signed at the city of Ramsar in Iran, and so is known as the Ramsar Convention. Australia was the first to sign and therefore, has an obligation to designate wetlands to be included in the List of Wetlands of International Importance. Australia is also obliged to conserve wetlands and waterfowl within its territory by establishing nature reserves in wetlands and managing them effectively. We are also committed to establish a network of nature reserves and prepare wetland inventories. Our Government should be encouraged and supported in its efforts to bring into effect the agreements made under the Ramsar Convention.

Some countries have bilateral agreements to protect the habitats of waterbirds that migrate between them. In 1981, Australia ratified such an agreement with Japan, known as the Japan Australia Migratory Bird Agreement. Under this, Australia is to protect and manage the wetlands needed by many different species of migratory birds. A number of wetlands on our coastal plain here are known to support twenty species of migratory birds and so logically would be subject to this agreement. A similar treaty is being developed with China.

In common with a large population of the international community then, Australia has recognised the need to conserve wetlands. It is therefore incumbent on us to ensure that we give substance to this sentiment.

TEACHING AND LEARNING

The remaining wetlands of the coastal plain are near a large proportion of this State's population, its schools and tertiary training institutions. With the lives of so many of our young people increasingly dominated by an artificial urban environment, refuges where nature performs unabated are becoming more important. Learning about nature can give them a more balanced perspective of the world and engender a sensitivity towards all forms of life. In widening their appreciation of the world around them their quality of life may be enhanced immeasurably. Of course, this type of learning applies equally to the adults of our community, but we have a particular obligation to the young not to foreclose their options.

Our coastal wetlands provide a focus for learning about the creatures and plants of this planet, and their interdependence, because they have such a diversity of wildlife. Many are within easy reach of most people, by foot, bike, car or bus. School teachers and lecturers would therefore find the wetlands a valuable teaching resource for their students. The wetlands readily form the basis for special study projects as well as a normal component of the biological sciences.

At the tertiary level, students of ecology, environmental science, botany, zoology and hydrology all need wetlands to complete their education. Also they are now the centre of much research interest, the continuation of which is essential to our understanding of how they work, and what relationship they have with groundwater quality and quantity. The ready accessibility of the Swan Coastal Plain wetlands for these purposes is an obvious benefit.

RECREATION AND RESPITE

Recreation means different things to different people. For many of us water-based recreation conjures up images of sail boats, water skiing, speed boats, kayaks, the Avon Descent, sailboards, fishing and swimming. Certainly many people follow these pursuits on the larger rivers and estuaries. In fact, much of the outdoor lifestyle enjoyed by the people of Perth is centred on the recreational use of wetlands and ocean beaches. Our long hot summers attract people to water and we are favoured in having so much at our doorstep.

More passive activities are equally recreational and can be pursued by a greater number of people because they are less demanding physically and financially. Our coastal wetlands are particularly well suited to picnicing, bushwalking, photography, painting and birdwatching for example. While wetlands are not essential to these activities, they elevate the recreational experience.

With imaginative and sensitive planning, bushland and wetlands can be incorporated into attractive reserves for conservation and recreation to the benefit of a great many people. To retain their value will require a commitment to careful management, but the rewards for doing so will be great. This unique opportunity we have to conserve and enhance the recreational value of our wetlands and associated woodlands will not be lost if we act now.

THE VIEW AND COMMERCE

So many people say the view across water is beautiful that it must be true. Whether tranquil or agitated, blanketed in mist or reflective, water holds an unending fascination for most of us. Because of this, the naturalness of any setting is enhanced enormously when it has a view of water. Natural areas are constantly sought after by urban dwellers, as places to live or simply visit, and those with a view of water are pursued the most vigorously.

Society therefore places great value on wetlands because they provide scenery which is pleasing, active and interesting. Town planners and urban designers recognise this value and now give a great deal of thought to achieving the highest possible benefit for the community from the wetlands within their sphere of responsibility. Such blending with nature is not without its problems, but those who tackle this task are to be applauded since their decisions enable us to retain an irreplaceable social asset.

The commercial value of a wetland setting is well appreciated by developers and real estate people. Buyers will always pay a premium for land and housing with views of a lake, river or estuary. Even land in close proximity to these areas is well sought after. In some of the new housing estates land values have been increased by the creation of artificial wetlands. Although any possible adverse consequences of these developments need to be considered carefully, they do illustrate the desires of many people to be near water.

Other commercial values can also be ascribed to wetlands. The shallow waters of the estuaries function as nurseries for much of the fish caught by professional and amateur fishermen along our coastline. Supplying fishing gear to the amateurs is the basis for yet another industry. To protect our fishing industry therefore, the fish nurseries of the Swan and Canning Rivers, the Peel/Harvey and Leschenault inlets, and the south coastal estuaries and inlets must be protected.

Some birds of the wetlands help control insects which may threaten various agricultural activities. Ibis for example, have sickle-shaped bills to probe waterlogged soils for beetle larvae, worms and frogs. They are also very fond of grasshoppers and will fly long distances in pursuit of them. Ibis are large birds and can devour large numbers of grasshoppers and so help farmers protect their crops from the devastating effects of the plague locust.

TOURISM

Australia's popularity as a destination for international tourists appears to be increasing. The media often refer to tourism as our new growth industry and it seems that, above all, what tourists want to see are things Australian. What our wetlands can present to them are their many plants and animals which are uniquely Australian. Thus we have a tremendous opportunity to capitalise on the tourist potential of our coastal wetlands.

One of the newer developments in tourism is catering for the needs of special interest groups, which goes beyond traditional sight-seeing. Bird watching, for example, is an increasing attraction for visitors to our country, and in recent times several groups have come to Australia for this express purpose. The wetlands are ideal places to follow this interest, especially with natural bushland nearby.

The wetlands of the coastal plain here could be a major tourist attraction. They are located near an international airport, high quality tourist accommodation is close by and we have several wetlands of international significance. Of course, any development for tourism would need to be planned with great sensitivity to conserve as many natural features as possible. Tourism and conservation are not incompatible provided the reserves are large enough and are skillfully managed.

Every year many thousands of tourists visit the Everglades National Park and the Great Swamp Wildlife Refuge in the United State of America. The visitors pay willingly so the revenue is considerable and is put to manage and conserve these remarkable wetlands. The unique features of all our wetlands and the international importance of some provide a strong case for similar developments here. Tourists would have an additional incentive to include Perth in their itineraries and revenue would be generated for wetland conservation.

HERITAGE

Before European settlement Australia has a prehistory of at least 40,000 years of Aboriginal occupation. For the Nyoongars of the South West, the coastal wetlands were essential for food and water in the summer months. Many of these wetlands on the Swan Coastal Plain were seasonal camping sites which can still be identified from sharp quartz chips used by the Aborigines in spear heads and for food preparation. There the Nyoongars found an abundance of game: waterfowl, tortoise and animals that came from the bushland to drink. The bulbous roots of the bullrush was also a valued food. Some freshwater wetlands were particularly suitable staging posts from which the saline estuaries could be fished. In the winter, the Nyoongars moved off the wet coastal plain to beyond the Darling Scarp where ephemeral water holes and streams allowed them to hunt and gather food over a much wide territory.

The Swan Coastal wetlands and their ancient campsites therefore, have great significance for Aborigines, a heritage value the whole community is learning to appreciate.

Since 1829, under the influence of European culture and aspirations, this land has been extensively modified, reshaped and exploited to yield a very high standard of living. But this wealth has been achieved at some cost to the environment. So along with the benefits of our inheritance has come its accumulated problems and losses, the collective result of small decisions made on the basis of what seemed reasonable at the time.

Obviously, the settlers of the last century placed little value on the pristine wetlands of the coastal plain, and in fact saw them as obstacles to progress. This view persisted well into this century when most of the draining and filling took place until quite recently. There is now a resistance to any further destruction of the wetlands, stemming from a greater understanding and appreciation of their intrinsic value. It seems that, looking beyond the year 2000, one can reasonably expect future generations to value wetlands even more. As the decisions made now will determine the state of their inheritance, we should be prepared to make large decisions with a time scale that extends well beyond the immediate future.

THE HISTORY AND TENURE OF WETLANDS

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ABSTRACT

The history of perceptions, attitudes towards, and uses of wetlands in the Swan Coastal Plain goes back many thousands of years.

Aboriginal society made widespread use of wetlands for a long period prior to European settlement. Aborigines understood the wetlands, appreciated them and depended upon them. Wetlands provided water, abundant food, sacred sites and places of ritual. Aboriginal empathy, integration and spiritual attachment with nature extended to wetlands.

Early European settlers struggled to survive in what they often perceived as an alien and hostile environment. Wetlands were an obstruction to travel, difficult to alter and not generally viewed as visually pleasing. Yet they provided accessible water supplies and were soon recognised as suitable locations for cultivation of essential food.

As Western Australian society matured and grew, so did its appreciation and understanding of the local environment. While an aesthetic appreciation developed for locally distinctive landscapes such as wetlands, a utilitarian attitude generally prevailed. Such issues as drainage and flood control, health and the need for fertile productive soils dominated.

Latterly there has been enormous expansion of population and development on the coastal plain. We can now look back on a complex pattern of usage and change in wetlands. In recent years there has been an upsurge in interest, understanding and concern for wetlands. The way in which wetlands are perceived has radically altered.

Tenure of wetlands is correspondingly varied and complex. Possibly every variation of tenure and control could be found to apply to some wetland or other. This includes Crown Land, alienated land, combinations of both, single ownership, multiple ownership, control under many Acts including those governing water resources and land use development.

Tenure can be viewed as a tool for exerting control and rights over an exploitable resource. Tenure as it is applied to wetlands is in this sense the end product of cultural practices, societal perception of the environment, society's technological capacity, and society's exploitive tendencies and preferences.

CONTENTS

INTRODUCTION

The history of human perception, attitude towards and use of wetlands* on the Swan Coastal Plain is varied. It goes back many thousands of years and over the majority of this period the relationship between people and wetlands must have been relatively stable.

Recent history over the last 160 years has, by comparison, seen some noticeable shifts in attitude and treatment of wetlands. This same period has featured widespread modification as well as eradication of many wetlands of the coastal plain.

A GEOLOGICAL PERSPECTIVE

Few people who have analysed the physical character of the coastal plain would disagree that wetlands are a dominant landscape feature. As such they have greatly influenced land-use patterns since European settlement, and indeed before. Yet because of their apparent permanence, it is easy to overlook the transitory nature of wetlands. A geological perspective is useful.

Figure 1 indicates the changes in sea level and coastal landform going back several thousand years, which were associated with the ice-age and subsequent period. Given that there has been dramatic variation as recent as 6000 to 8000 years B.P., and that only 50,000 years B.P. the shoreline was well beyond Rottnest Island at 50 metres below the present sea level, hydrogeological conditions on the coastal plain would have been drastically affected. It is therefore obvious that the wetlands themselves stem in origin from the fluctuations of this geological period, and this provides a useful context to understanding their transitory nature in geological terms.

Associated with the various geological changes have been the much more varied fluctuations in climate and long-term weather patterns. There is abundant evidence from the stratigraphy of lakes (core samples etc.) to indicate the variations in water levels and therefore physical characteristics of many wetlands that have occurred over relatively short as well as longer periods. This is another reminder of the transitory and recent nature of wetlands as features in the coastal plain environment.

ABORIGINAL USE OF WETLANDS

Aborigines existed in what is now the Perth metropolitan region 34 000 years before the great pyramids of Egypt were built, and 37 800 years before European settlement of the coastal plain (Green, 1984).

Footnote * Wetlands are defined as 'Areas of seasonally, intermittently or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh or saline, eg water-logged soils, ponds, billabongs, lakes, swamps, tidal flats, estuaries, rivers and their tributaries': Department of Conservation and Environment (1977).

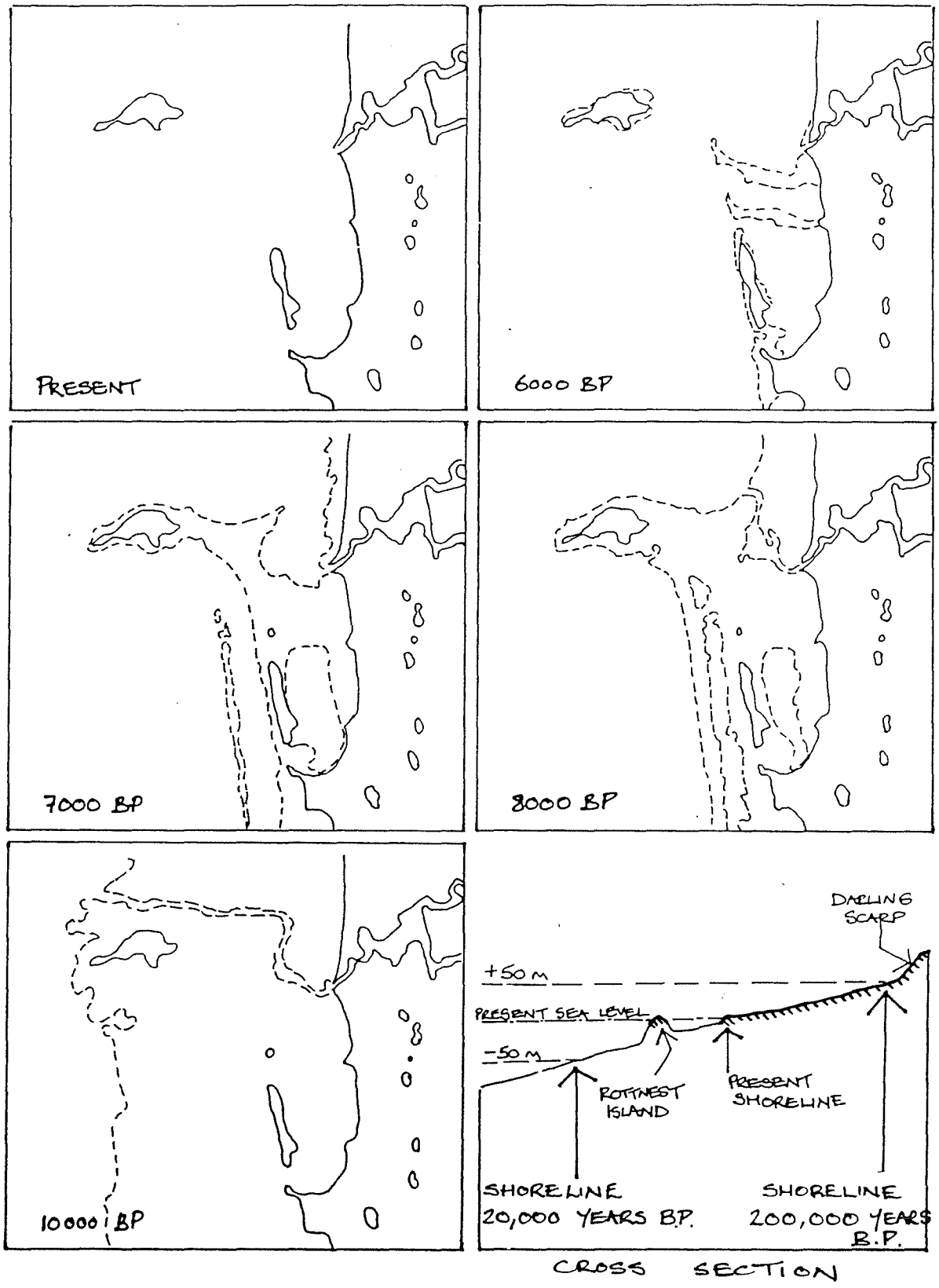


Figure 1. Changes in sea level and coastal landform.

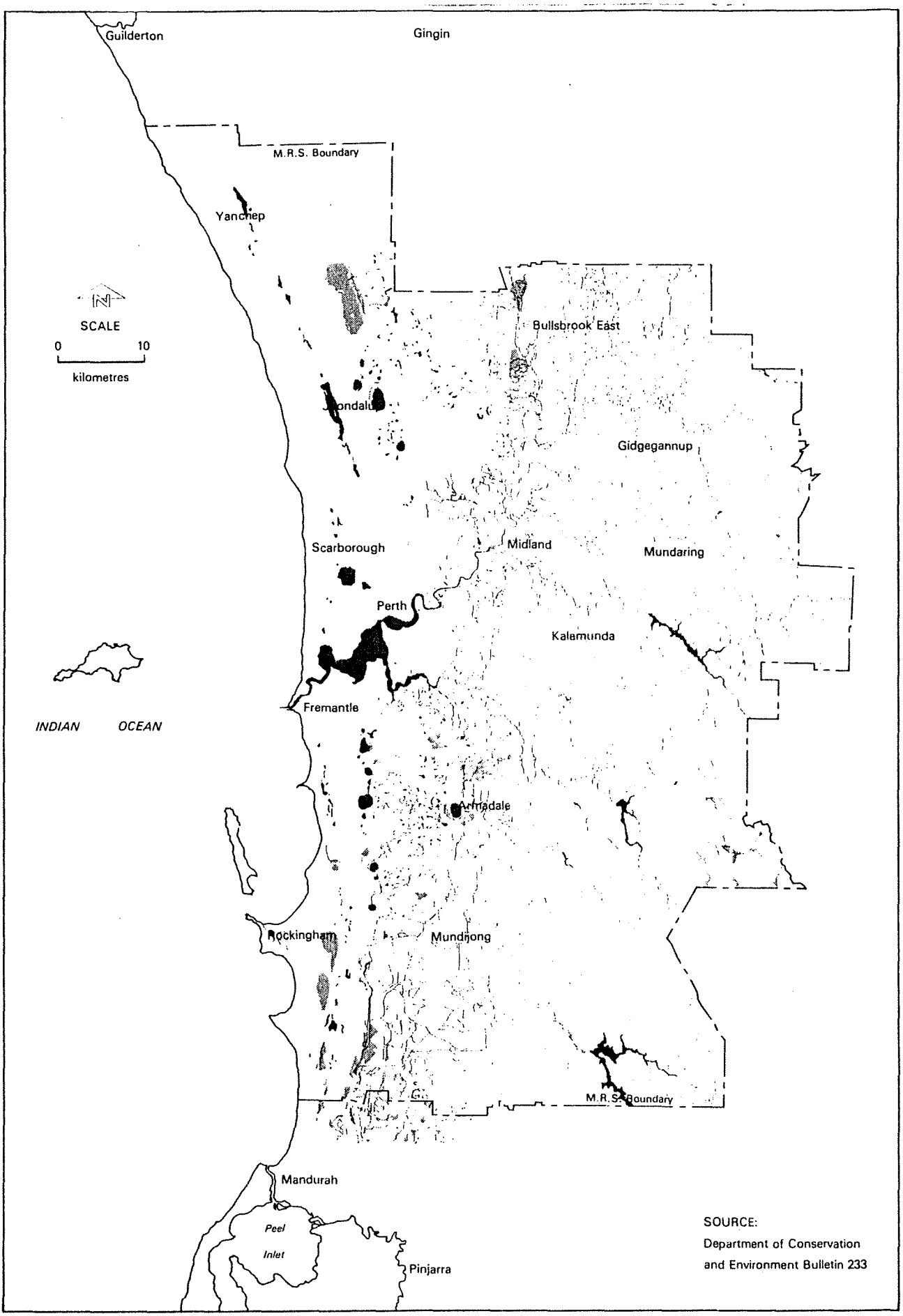


Figure 2. Natural drainage and wetlands.

The Nyungar territory extended over the fertile triangle of the South-West, bounded by a line from Geraldton to near Esperance. The coastal plain was comparatively well-watered, providing an abundance of pools, springs, swamps and lakes where palatable water was easily obtained. This 'coastland' was an important source of summer subsistence food for the Nyungar.

The estuaries provided plentiful teal, black ducks, swans and pelicans all of which were favoured foods. The extensive systems of brackish lakes between Mandurah and the Moore River provided Nyungar family groups with an inexhaustible summer food supply of frogs, turtle, fish and marron. Wetland vegetation, especially reeds, yielded nesting sites for birdlife and provided edible roots. Aborigines often fired the dry reed beds of the swamps in summer to assist in the hunting and gathering of these various animals (Hallam, 1979). Melaleucas and other wetland associated vegetation provided materials such as the paper-like bark to waterproof their shelters, to contain water and wrap food for cooking purposes (Green, 1984).

While water supply was an obvious value of wetlands, it is interesting to note that Aborigines are known to have dug wells, particularly in summer (Hallam, 1979). Apparently they would dig wells beside and relatively close to a wetland body (O'Connor, 1986 pers. comm.). Water seepage through highly leached sands or peat would have purified otherwise brackish water to some degree.

Wetlands had importance to Aborigines for things other than food gathering and water. They were often a focus for camping sites, they provided sites of sacred or mythological significance, and they were often associated with 'avoidance' sites. Aspects of ritual and corroboree areas were often in association with a wetland environment. The literature also indicates the frequent Aboriginal belief of a Waugal (or Wagal) associated with wet areas, springs or creeks. (Hallam, 1979; O'Connor et al; 1985). Some recorded Aboriginal explanations of Waugals seem to indicate the recognition by Aborigines of a type of connection, possibly hydrological, between different water bodies, rivers or creeks.

ABORIGINAL PERCEPTION AND TENURE OF WETLANDS

A survey of Aboriginal areas of significance in the Perth Metropolitan Region compiled in 1985 appears to underline the importance of wetlands (O'Connor et al; 1985). Of a total 69 sites listed in the preliminary report, 51 have direct reference to a wetland of some sort. In the majority of cases, the wetland is clearly central to the significance of the site concerned.

It is also logical to suggest that the Aboriginal mental-map of the coastal plain strongly featured wetland landscapes. (O'Connor, pers. comm.; Singleton, 1987). Early European settlers were aware of the network of Aboriginal tracks which linked a variety of nodes at all types of water source (Hallam, 1979). There is specific reference in the literature to known tracks crossing rivers at particular points and passing such wetlands as Bibra and Lake Monger (Hammond, 1933).

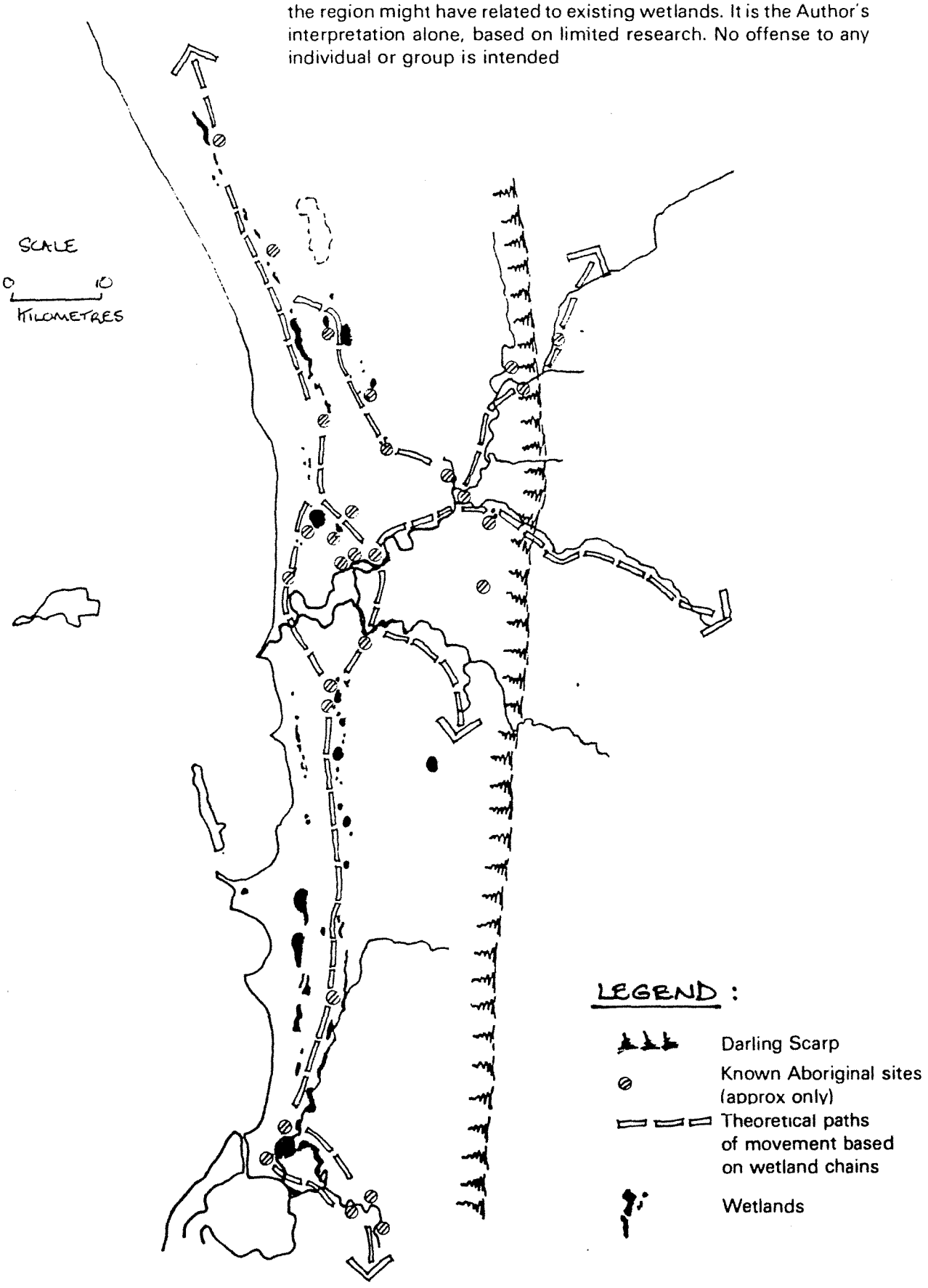


Figure 3. Aboriginal movement and wetlands.

Tenure is something Aborigines did not have in the European sense. Unlike the Europeans, they saw themselves as a part of the environment and as one with their territory. They could never dispose of that which they held in trust or owned, as their spiritual self and tribal welfare were inextricably bound up with the environment. However, Nyungar groups had identified territory and would actively invite other groups to share food sources, or repel trespassers as the situation dictated (Green, 1984).

EARLY EUROPEAN SETTLEMENT AND THE WETLANDS

THE FIRST SETTLERS

For the early settlers and long after, the wetlands were both a curse and a blessing. They epitomised them, and still do today, an ironic duality of the coastal plain environment; the searing hot and arid summer conditions, versus the extremely wet humid winters with high water-tables and widespread inundation. So the wetlands variously provided ready water supplies, productive soils for cultivation, obstructions to movement, mosquitoes, winter inundation and concerns for health. (Ravine, 1986; Pitt Morison, 1979).

The first settlers, of course, had imperatives for water, fertile soils and watering points for horses and stock. At the outset, they also followed the long-standing Aboriginal tracks that followed the wetland chains, and that linked many swamps, springs and lakes (Green, 1984)

The original settlement of Perth was first established on a ridge to the east of Mt Eliza, overlooking the Swan River to the south and east and with a chain of wetlands to the north. These wetlands included Lakes Kingsford, Irwin, Sutherland and Henderson, which were connected by the Claise Brook to the Swan River. Lake Kingsford was drained in 1847, following the flooding of what is now Forrest Place. Seven years after, lots on the site of the lake were put up for sale.

By 1900 nearly all the original wetlands of this system had been modified to become a deep drainage system. In the intervening period they had been put to a variety of uses which included market gardening, municipal gardens, town rubbish dump as well as a proposal to draw water from another nearby lake for the Town's water supply (Figure 4).

Seddon (1972) refers to the way in which the majority of these wetlands were drained as the city expanded during the nineteenth century. For example:

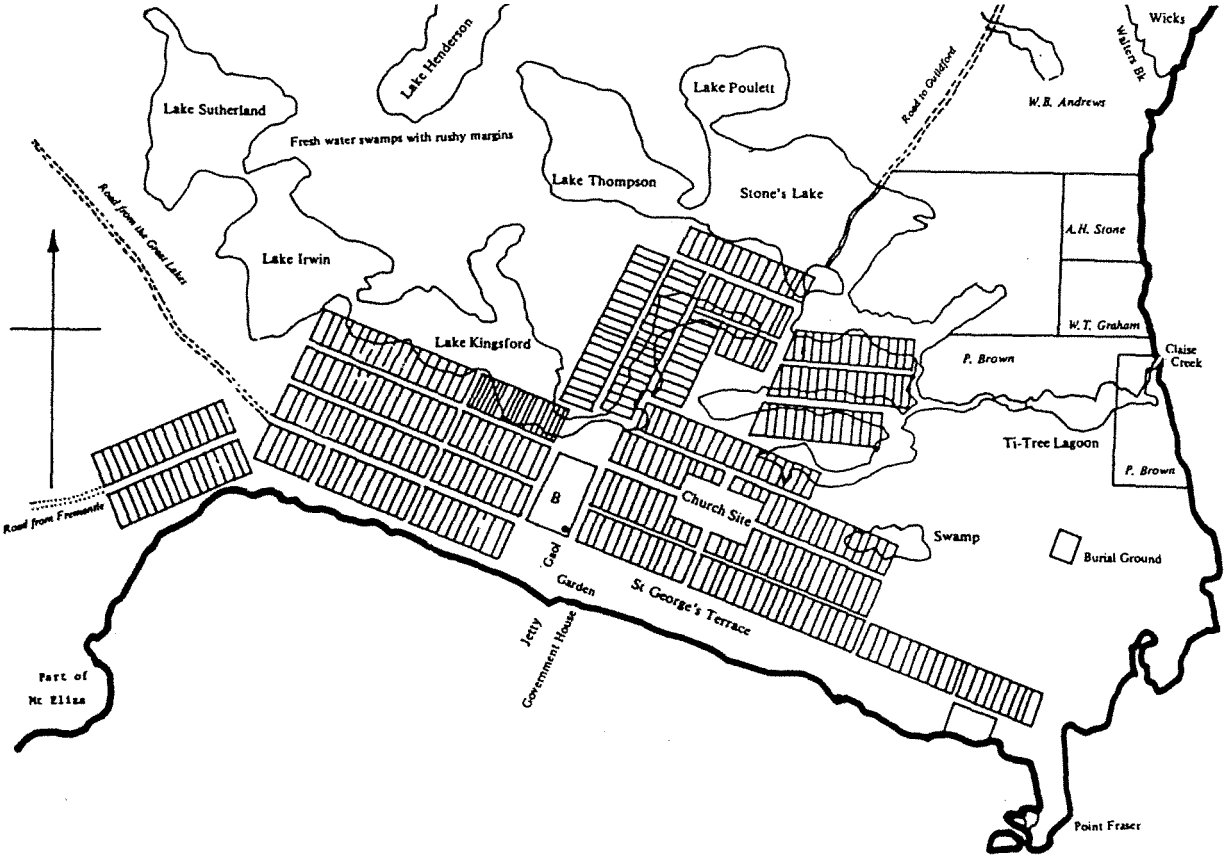


Fig. 15.1 The '1833 Plan' of Perth. This is a modified copy of the plan which was drawn originally as an inset in the map of Western Australia prepared by the famous London cartographer, John Arrowsmith, from 'documents furnished to the Colonial Office by J. S. Roe, Esq., Surveyor General'.

Note particularly:

1. The many freshwater lakes north of Perth and Claise Brook (Claise Creek)
2. St Georges Terrace which runs the full length of the town and is, in the east, a true 'terrace' in that there are no allotments between it and the river at this stage
3. Point Fraser, which was to disappear many years later when land was reclaimed from the river to form the present Langley Park
4. The original position of Government House
5. The 'garden' planted by the Colonial Botanist, James Drummond
6. The 'Burial Ground' which became known as the East Perth Cemetery
7. The roads to Fremantle, Guildford and the 'Great Lakes' (Monger and Herdsman)
8. Location B—the 'Town Square'

SOURCE: GENTILLI(1979)

Figure 4. The 1933 plan for Perth.

LAKE	YEAR DRAINED	USE
Georgiana	1870s	Suggested water supply
Henderson	1870-1873	Market gardening then municipal park
Poulett	1872	Town dump, Chinese market gardens then town square
Thomson	1873	-
Third Swamp	-	Converted into a formal lake
Osborne Park Swamps	1912	Market gardens
Herdsman Lake	1925	Market garden - then allowed to revert

Seddon and Ravine (1986) go into considerable detail as to how in 1848 the Health Committee of the early settlement of Perth under John Septimus Roe, assessed the complex drainage difficulties presented by the wetlands in question and the works devised and implemented to transform them by the 1850s.

AS TIME WENT BY

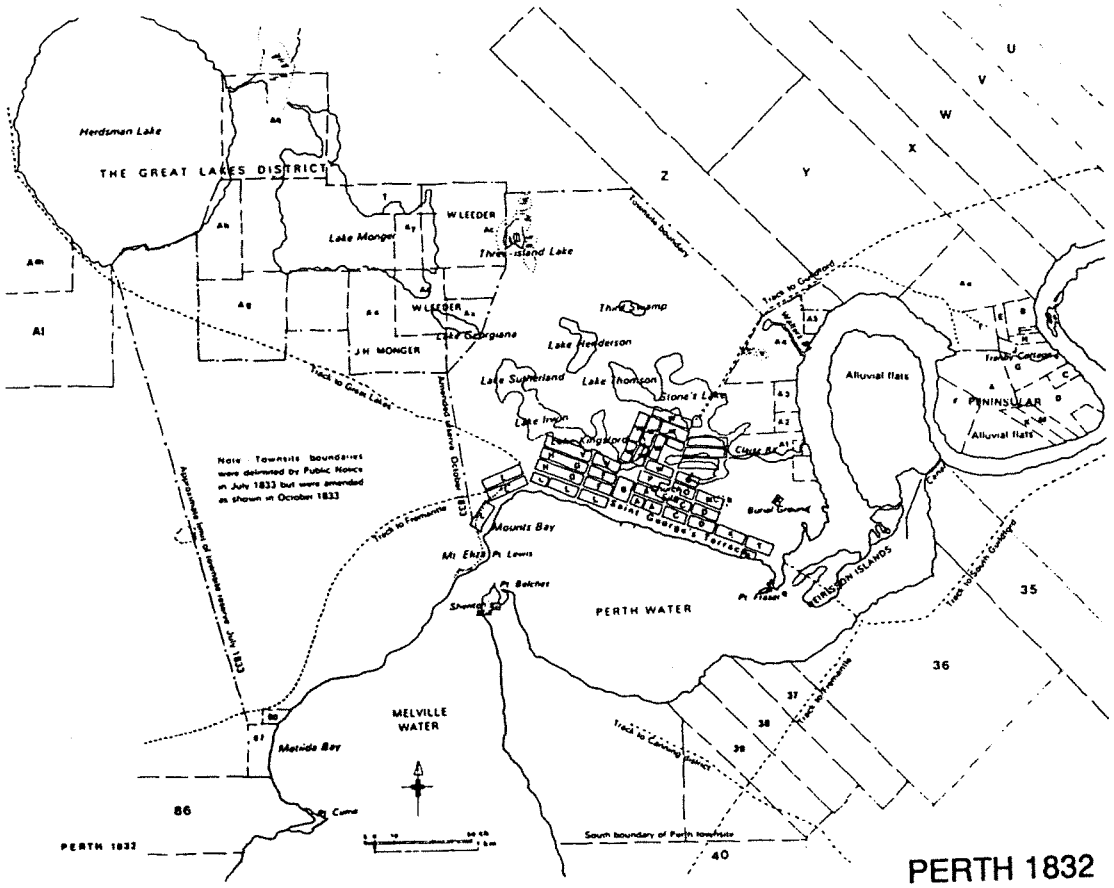
As the early Swan River settlement expanded, so the most recent arrivals (or the least influential) started to move further afield looking for alternative soils suitable for production. This led to market garden developments in such places as Wanneroo. For example, a partnership of T Hester, G Hodges, J Dobbins and J Connolly first took up land for cultivation on the southern shores of Lake Joondalup in 1837-38 (Ruscoe, 1977).

The spread of early settlement affected many different wetlands. Lake Monger has a long history of use and tenure for example. Subdivision plans of Perth as early as 1832 show Lake Monger subdivided into 8 lots. This subdivision pattern appears to have remained unchanged to about the 1860s. A Mr J H Monger was the first to receive a 200 acre grant of land which he held for many years. By the end of the 19th Century, other settlers were appearing near Monger's Lake (C Miller, 1980).

Mr Herdsman took up land by "a bigger lake half a mile distant" (C Miller, 1980). By 1883 there was a plan advertised in the Inquirer newspaper by the Reverend Gidney to cut a channel in order to drain the whole of Herdsman Lake. This was intended to reclaim the lake for agricultural use in the interests of an orphanage established close by.

Naturally many wetlands in the region were named as a result of the earliest settlers, users and land-owners. Dyson's Swamp, now known as Shenton Park Lake, named after Dyson and Butler's Swamp, now Lake Claremont, named after Mr Butler, are examples.

Another well known wetland is Perry Lakes named after Joe Perry. Perry was the official town herdsman as a boy, but astute enough as he grew to begin by catching wild ponies in the Wanneroo area, selling them in Perth and purchasing allotments with the earnings.



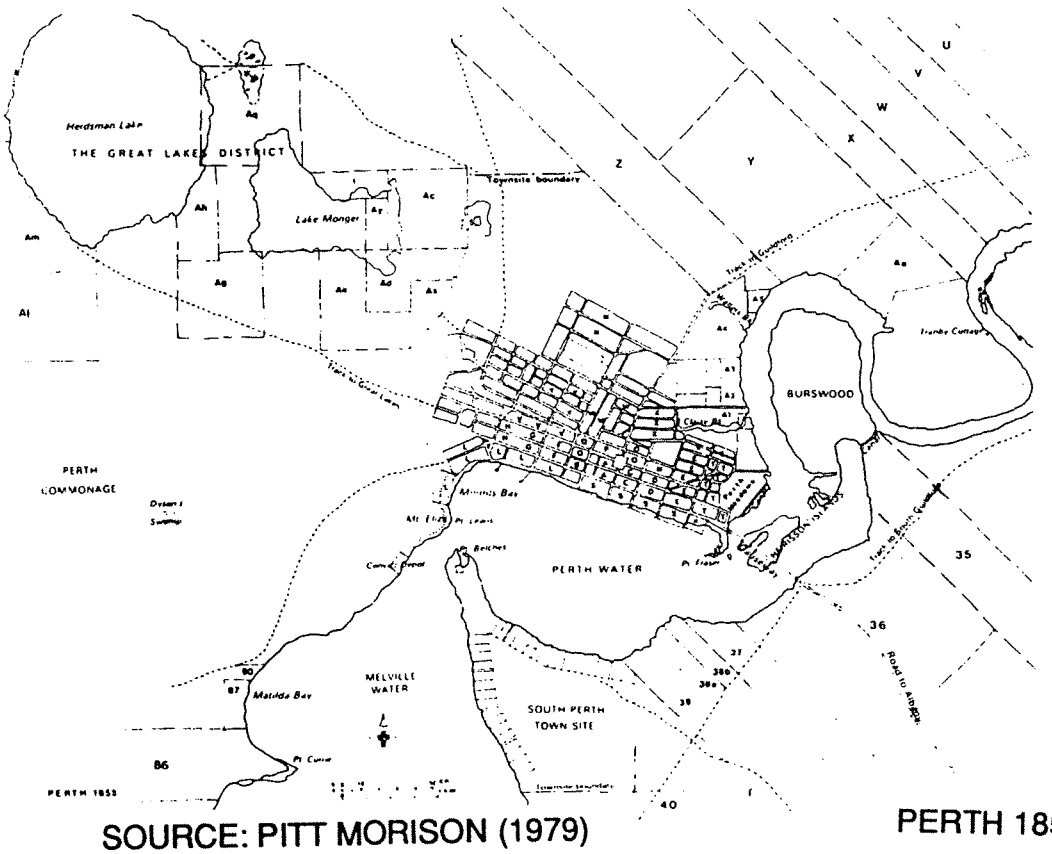
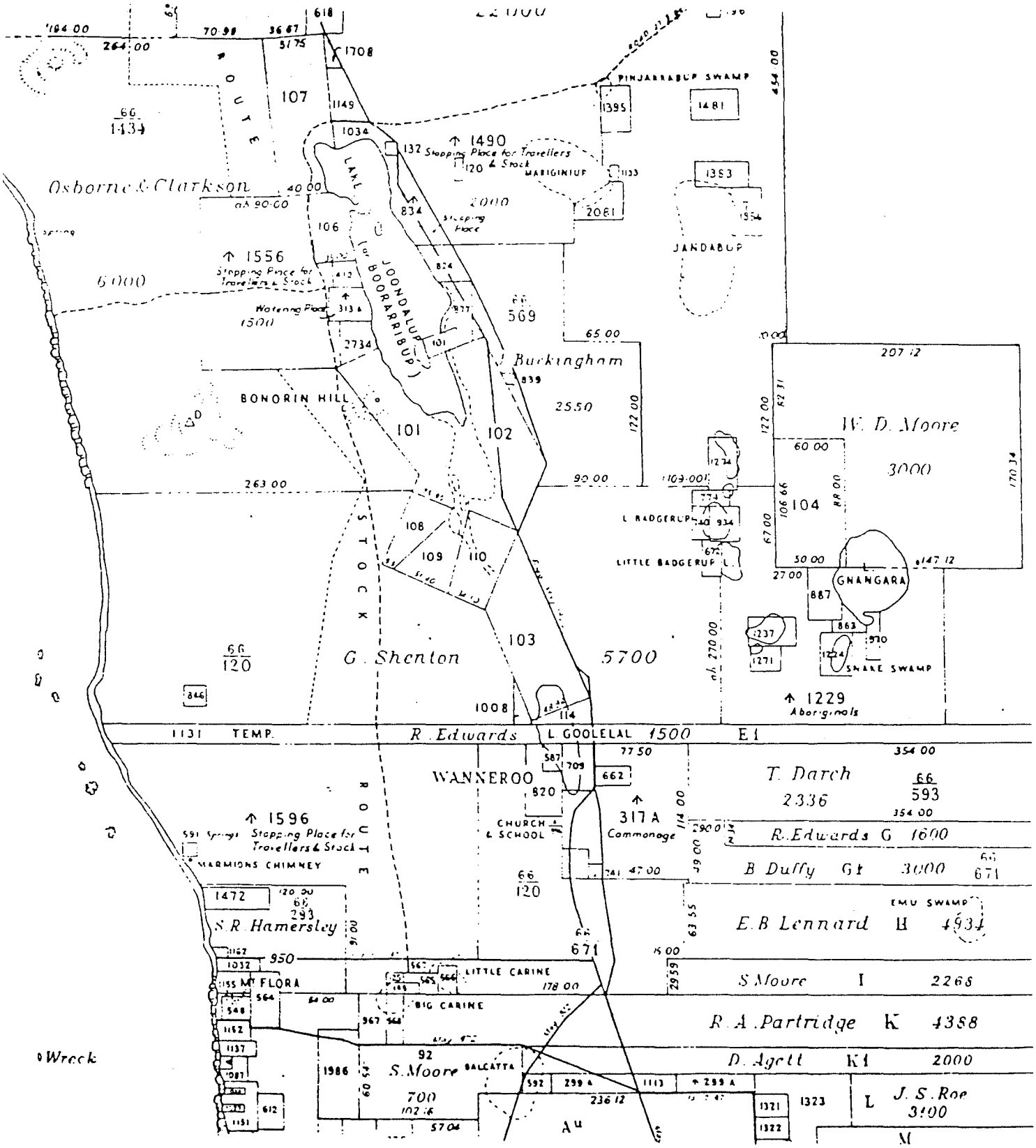


Figure 5. The spread of early settlement.



SOURCE: RUSCOE (1977)

Figure 6. Early subdivision - Wanneru District.

CROWN GRANT REFERENCE

Nº	Grantee	Date	Nº	Grantee	Date
101	K S Rogers	1876	1145	J Lloyd	1876
102	—	"	1221	J Thompson	"
104	J Connolly	"	1274	T S Dorch	"
105	G B Haggrs	"	1726	—	"
110	J Dobbins	"	625	G Shenton	1881
103	S Moore	1842	857	Church of England	"
104	"	"	1237	R A Snow & Calloway	"
105	"	"	956	Joseph Shaw	1883
106	E Jeffers	"	765	H Gibbs	1884
107	F Cullwick & W H Mackie	"	674	J Buckingham	"
113	W Macdermott	1843	639	—	"
112	M Hutton	"	663	F Andrews	"
111	—	1844	934	T S Dorch	"
120	J Smith	1855	970	F Andrews	"
132	P Moore	"	1008	G Shenton	"
156	J Smith	1865	1034	J Buckingham	"
412	A Taylor	"	1224	Elizabeth Stott	"
422	E M Roe	1857	1271	G Leach	"
535	R De Burgh	"	1383	Alexander Forrest	"
709	B Duffy	1870	1681	J McCaffrey	"
645	G Shenton	"	2061	A M & T Wade	"
567	"	1872	2734	Exec of W R Firth	"
591	Harris & Co	"	2751	J Gibbs	"
662	George King	1875	1162	—	1886
672	T Dorch	1876	1472	—	"
740	"	"	781	William Hork	1887
877	J Buckingham	"	3301	—	"
894	Schoolsite	"	1133	J Wade	1888
618	J G Truslove	1878	1395	"	"
741	B Duffy	"			
774	T Dorch	"			

LEASE REFERENCE

* Nº	† Lessee	Date	Nº	Lessee	Date
66/120	G Shenton	1887	66/1257	Higham & Moley	1885
" 243	S R Hamersley	"	" 1324	W T King	"
" 508	W D Moore	"	" 1340	L B Lukin	"
" 569	J Buckingham	"	" 1348	C Lloyd	"
" 593	T Dorch	"	" 1434	Osborne& Clarkson	"
" 671		1888	" 1457	W Rock	"
" 728	W A Dewer	"	" 1687	S Mortimer	1889
" 1017	D King	"	" 1756	Bank of N S W	"
" 1165	B D Clarkson	"	" 1913	John Christian	"
" 1237	Hy Gibbs	"	" 2028	J Buckingham	1891
" 1238	"	"	[illegible] 2188	W T King	"

* 66 refers to Regulation 66 (S W Division) Gov.Gaz 2-3-1887. Pastoral Leases generally were a minimum area of 3000 acres at a rent of £1 per 1000 acres

† Lessee shown is as at 1880. Areas were leased as early as 1850 with most Leases being granted in the early 1870's

Legend to Figure 6.

He prospered and established a butchers business, using his land at Perry Lakes to fatten his cattle. When he died in 1920 his estate was valued at 250 000 pounds (Stannage, 1979).

Other recorded associations between wetland and settler include Lake Manning (Davilak) which features the Azelia Lea homestead of the Manning family. There is Bibra Lake which may have got its name from Colonel Von Bibra, a Murchison pastoralist and racing personality, and McDougall Park Lake in Como with McDougall's dairy farm nearby. J and W Bateman, grocer and merchant of Fremantle, grew vegetables in and around Blue Gum Swamp at Bull Creek. For some unknown reason nearby Booragoon Lake was left unused and unchanged. (Stannage, 1979; J Arnold, pers. comm.)

LAKE JOONDALUP

Lake Joondalup, Beenyup and Wallubuenup Swamps and Lake Goollelal are a good example of a large, directly-linked wetland system at a further distance from Perth, and with some interesting history that well reflects patterns of use and tenure of wetlands up to the present day.

Following the earliest settlement in 1837-38, further settlers moved into the area in the 1840s. These included William Rogers, Samuel Moore, George Shenton and James Cockman. However, development in this relatively out of the way place was confined to a narrow strip of no more than two miles width around the lakes. Development was restricted to farming until 1906 when the Government acquired Location 102 on the eastern shore of Joondalup itself, and subdivided it into 80-100 acre blocks and declared it a townsite. In 1907 the townsite of Wanneru was gazetted, and in May 1953 the spelling was amended to Wanneroo (R Ruscoe, 1977).

By the 1920s, two main areas had established, one on the east side of Lake Goollelal and the other on the south eastern side of Lake Joondalup. Dairy farms had become more widespread, and were established along the western side of Beenyup and Walubuenup swamps and on the south-western side of Lake Joondalup.

The general pattern of market gardening appears to have been a series of narrow properties, thirty two hectares being typical, extending back from a property boundary in the lake itself. In this way, ownership of the lake edge and adjacent productive land was spread amongst many individuals, which was later to provide considerable problems for control and management of the wetland. The common pattern of usage was for the two to three hectares of moist soil at the edge of the wetland to be worked. There was then the dwelling with the balance of the property being retained as uncleared bushland.

According to local enquiry (Chrisafulli, 1977; pers. comm.) market garden production was undertaken close to the water's edge, adjusting up or down slope with changes in water level (lake and water-table). Not until the 1930s did production move on to higher ground, when irrigation technology had advanced sufficiently to allow cheap, convenient and reliable pumping.

Enquiry also indicates that there have been considerable fluctuations in the water regime of both Joondalup and Goollelal. A resident recalls extremely low levels in the 1920s, such that it was possible to walk across any point of Lake Joondalup or Beenyup and Walubuenup swamps. Market gardeners began cultivation of the wetland bed and dairy farmers were able to graze their stock amongst the reed beds.

A conclusion to be drawn from the above is that as undisturbed or unmodified as wetlands might currently appear, considerable human use and impact has often been exerted on them in the past, even if of a comparatively non-permanent nature (Singleton, 1979).

FROM THE PRESENT DAY LOOKING BACK

URBAN DEVELOPMENT AND WETLANDS

Urban development in the region has been considerably influenced, hampered and encouraged by the existence of wetlands. In summary, one can say that the larger wetlands within the urban area mostly remain, even if variously modified, but smaller swamps were often eradicated. The reasons for modification and eradication are numerous, the most frequent being drainage to create more land for development and the convenient disposal of rubbish, the latter often in conjunction with the former.

Total figures are not available for the area of wetlands modified for various purposes. However it was estimated that in the period 1950 to 1976 some 121.4 hectares of wetland and a further 242.8 hectares of river foreshore had been reclaimed by landfill waste disposal methods, and that approximately 20.23 hectares/year were required to keep pace (Iveson, 1976).

A survey of the whole of the Swan Coastal Plain undertaken between 1964 and 1966, established that close to 50% of all wetlands had been eradicated (Riggert, 1966). It has also been estimated that some 200 000 hectares of land had been filled or drained by 1964 and that 40% of the remaining 65 000 hectares of wetland are reclaimable with existing technology (Department of Conservation & Environment, 1977).

A typical example of the way in which urban development has resulted in the disappearance of wetlands through drainage and landfill is shown in Figures 7 & 8 which illustrate natural and modified drainage before and after development of the suburbs of Bull Creek and Riverton (Stegena, 1975).

There are also examples of the way in which urban development has responded to the attractive landscape qualities of wetlands. Apart from the obvious case of the river foreshores, the best examples include the existing Wanneroo townsite on the east side of Lake Joondalup and the proposed Joondalup Regional Centre site on the limestone ridge west of Lake Joondalup, now being developed.

PAST USE AND PRESENT DEMANDS

In researching past and present use of wetlands, the literature available noticeably includes value judgements on the types of use documented. For example, in 'Guidelines to the Conservation and Management of Wetlands in Western Australia' (Dept of Conservation & Environment, 1977) under the section entitled 'the value of Wetlands and their importance in WA's developing economy' (Section 1) the following uses are mentioned:

Figure 7. Bull Creek - prior to urban development.

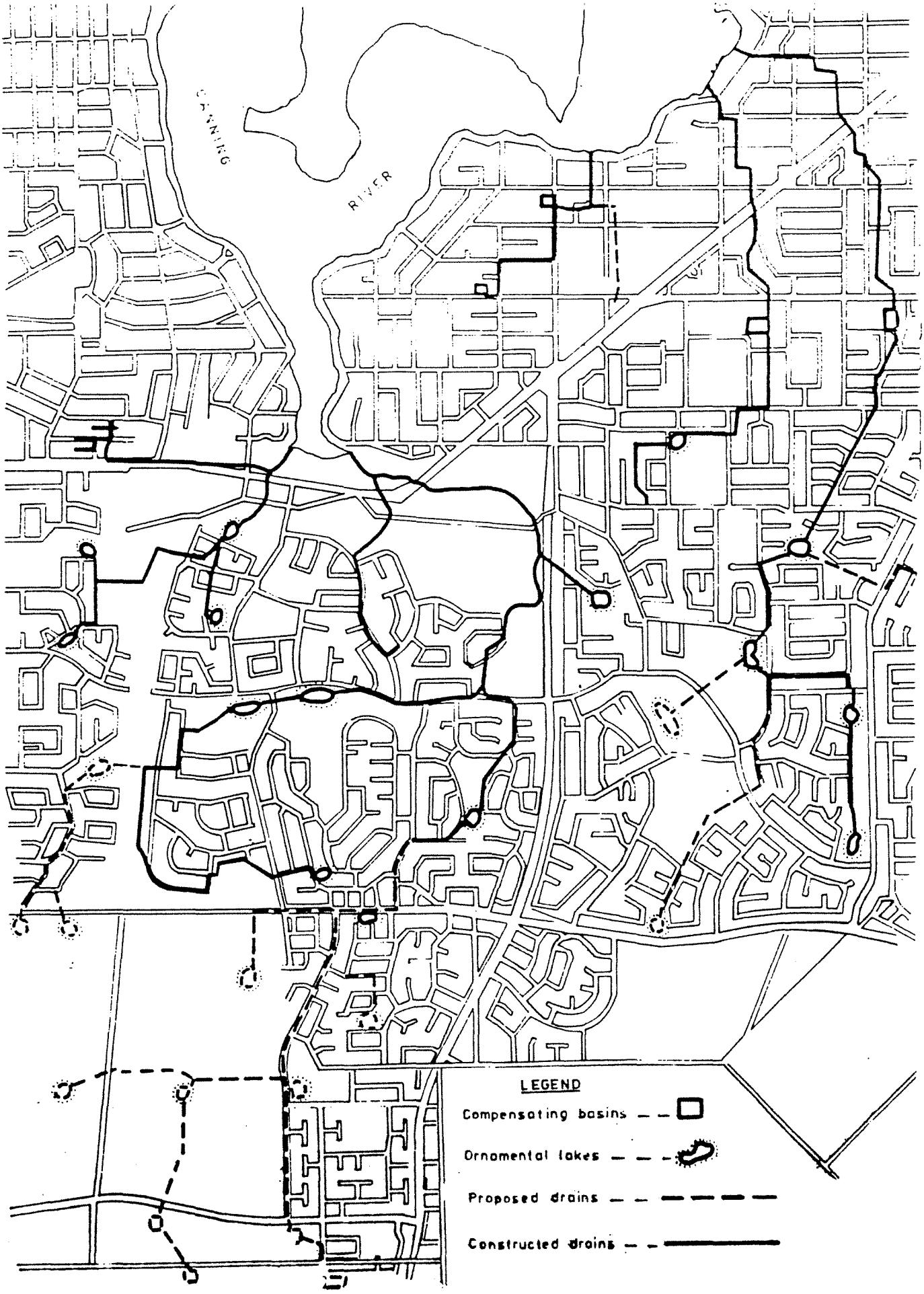


Figure 8. Bull Creek; Following urban development.

flora and fauna habitat; scientific research and education; water balance and drainage; maintenance of water quality of surface and groundwater; various recreation (active, passive) pursuits and scenic/landscape function.

On the other hand, under 'Wetlands - the dwindling resource' the report refers to the attitude of exploitation towards wetlands historically, and mentions the following uses:

transportation; water supply; drainage; waste disposal; mining; agriculture; filled areas to provide sites for housing estates and industry; rubbish dumps.

Nevertheless past use of wetlands in the Perth Metropolitan Region on the basis of observed land use, condition and the literature appears to include the following:

. utilisation for landscape settings and urban amenity;
. science and education;
. recreation and leisure;
. conservation;
. wildlife harvesting;
. food production (e.g. market gardening);
. mining;
. irrigation;
. water supply;
. urban drainage;
. disposal of waste material;
. reclamation.

The recent history of waste disposal and wetlands is worth considering briefly. A study in 1974 (Maunsells & Partners, 1974) produced a figure of solid waste production per capita/day at 2.27 kg for 1973, which resulted in 600 000 tons per annum for a total population of 739 000. It was projected that this would reach 2.82 kg/capita/day for a population of 1 074 000 by 1984 producing a total of 1 110 000 tonnes/year. It was also estimated that 20% of solid waste has to be disposed of by conventional landfill methods as it is not suitable for special waste treatment methods. Accepted practice of solid waste disposal sites at the time included limestone, sand or gravel quarries, or river and lakeside flats and wetlands. However, sanitary landfill associated with wetlands is now regarded as unacceptable for many reasons.

Recreation and 'parkland' has long been, and is increasingly, a recognised use of wetlands. They are now often viewed by local residents as neighbourhood assets. The planning process has responded to this and a large number of wetlands are reserved for Parks and Recreation. These include:

. Loch McNess and associated wetlands (also a National Park area);

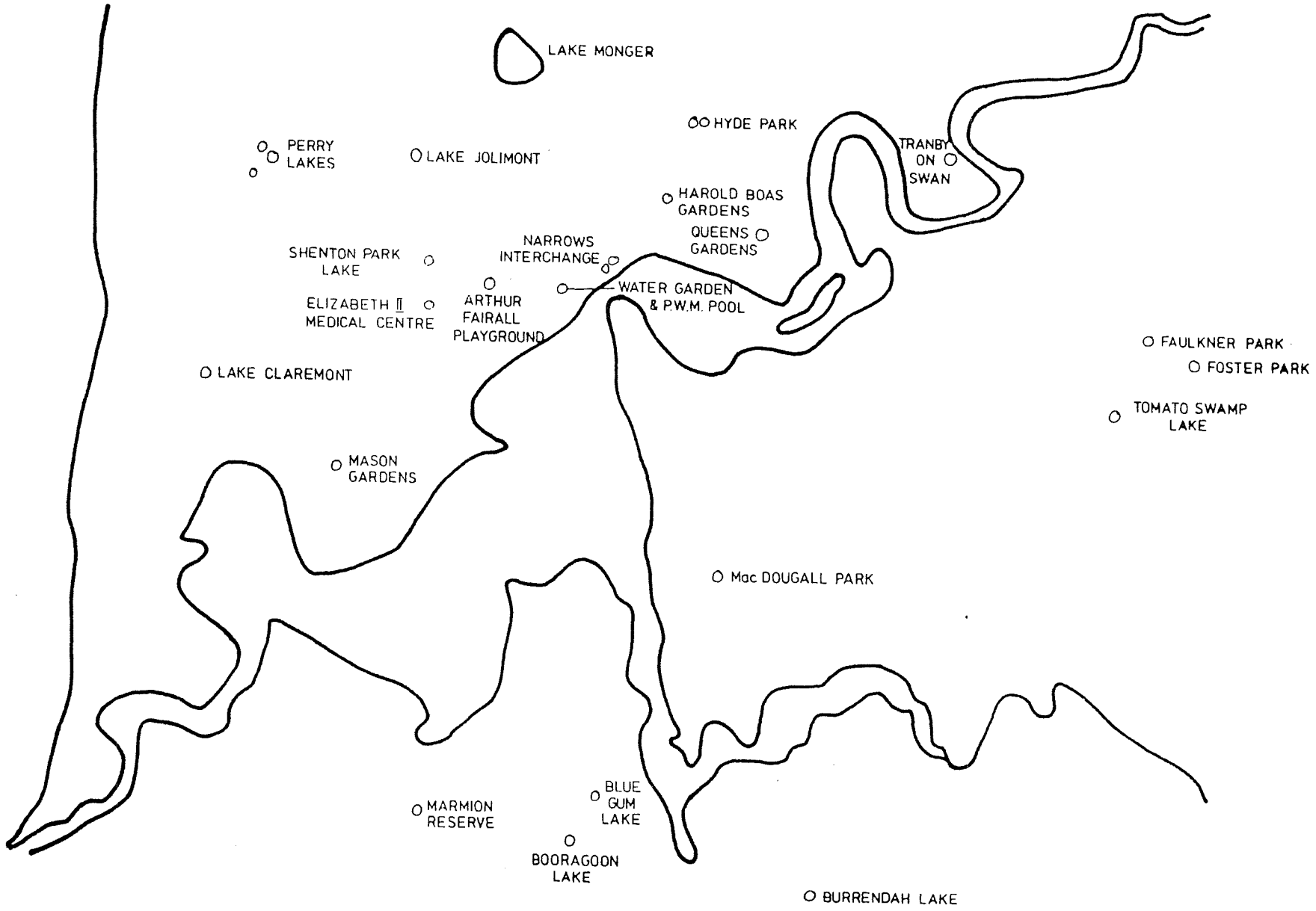
. Lake Nowergup;
. Lake Joondalup and associated wetlands;
. Carine and Erin Swamps;
. Lake Gwelup;
. Lake Monger;
. Lake Claremont;
. Perry Lakes;
. Bibra Lake;
. North Lake;
. Lake Yangebup and associated wetlands;
. Lakes Cooloongup and Walyungup (The Rockingham Lakes);
. Herdsman Lake.

However, most wetlands in the region are limited in the uses they can offer the public in their leisure time. A survey of fifty inland lakes (lentic wetlands) between Mandurah and the Moore River (1975-76) revealed that only 10% allowed for canoes or row boats, and 4% each for power boats and model boats. Swimming was found to be strictly prohibited in 26%, allowed but not feasible in 6%, and allowed and occurring in 10%. In that same survey it was found that for facilities adjacent to the water body, 14% had walking tracks, 24% had playgrounds, 8% had organised sport facilities and 14% had picnic facilities (Watkins, 1976). In summary, 82% of lakes did not at that time allow for recreation in or on the water body, and 50% of lakes did not cater for adjacent active or passive recreation facilities.

Finally, a survey of 22 wetland locations in the inner metropolitan area of Perth covering a series of smaller wetlands mostly designated as 'local open space' revealed the following information (Wycherley, 1978). Of the 22 wetlands (see Figure 9), 13 were considered 'natural' in origin, while 9 were considered artificial in origin (i.e. known to have been constructed or to have originally been clay pits, etc). Of these, 1 was little modified, 11 were moderately altered and 10 drastically modified. These included 1 with an adverse nutrient problem, 1 with an infestation of Salvinia (aquatic weed) and 4 with changes of a 'structural' nature. A breakdown of the functions or uses of the wetlands surveyed is as follows:

FUNCTION	NO OF LAKES
Landscape or ornamental	20
Natural origin with a drainage function	13
Artificial origin as sumps (drainage)	3
Major summer refuge for waterfowl	6
Minor summer refuge for waterfowl	10
With islands for waterfowl	8
With large reed beds for waterfowl	2
Feeding waterfowl a major attraction	7
Feeding waterfowl a minor attraction	5
Tortoise habitats	4
Observation post for bird watching, etc	1

In summary it appears that from the earliest days with the first settlers, those wetlands that could be drained were. Those that



SOURCE: WYCHERLEY 1976

Figure 9. Inner metropolitan lakes.

could have been drained but were not, were in many cases eventually converted into formal lakes in 'manicured' parkland. Wetlands too large to do anything with were perhaps slightly modified along their margins, but until recently mainly ignored (Hiller, 1977).

A fairly high degree of disinterest is apparent from the lack of data or past literature concerning wetlands, and it is really only in the last two decades that a significant increase in interest in wetlands has occurred. This appears to have gone hand in hand with the increase of public interest in environmental matters generally.

CULTURAL PERCEPTION OF LAKES AND SWAMPS

As features of the overall landscape, the way in which wetlands have been treated must also relate to matters of general perception.

Commonly-held views of the nature of lakes and swamps often differ from reality. Perception of water bodies is largely dependent upon the dominant image of the European or 'temperate' lake type characterised by deep clear water, firm sandy bottoms and rocky-stable shorelines.

Lentic wetlands of the coastal plain are characterised by a particular type of lake in both aesthetic and biological terms. Lantzke (1977) noted from observation of students that they initially want lakes like the stereotype of a European pond. They find shallow, organically rich water bodies, frequently with swamp-like littoral zones and a bottom of thick, odorous peat or mud. Insects abound and water levels drop in summer revealing mud banks and dry vegetation. While they are interesting and often attractive landscape features from a distance, at close quarters they are very different to the simplistic notion of an open pond or lake.

Little wonder this can result in unreasonable expectations of the use to which coastal plain wetlands can be put, and hostility towards them from the uninformed when expectations are not met.

Yet, once understood, our local wetlands can be seen as biologically highly productive environments, supporting a diversity of wildlife habitats, of immense value to birdlife, and having a distinct beauty of their own.

As such, they have their own very real uses and benefits to society.

TENURE OF WETLANDS

BROAD PATTERNS, RESERVES AND STATUTES

A ready observation from early tax sheets and cadastral plans of the coastal plain is the orientation of early subdivision patterns to wetlands of various sorts. Figure 10 clearly shows that a series of long, narrow blocks running at right angles to the Swan

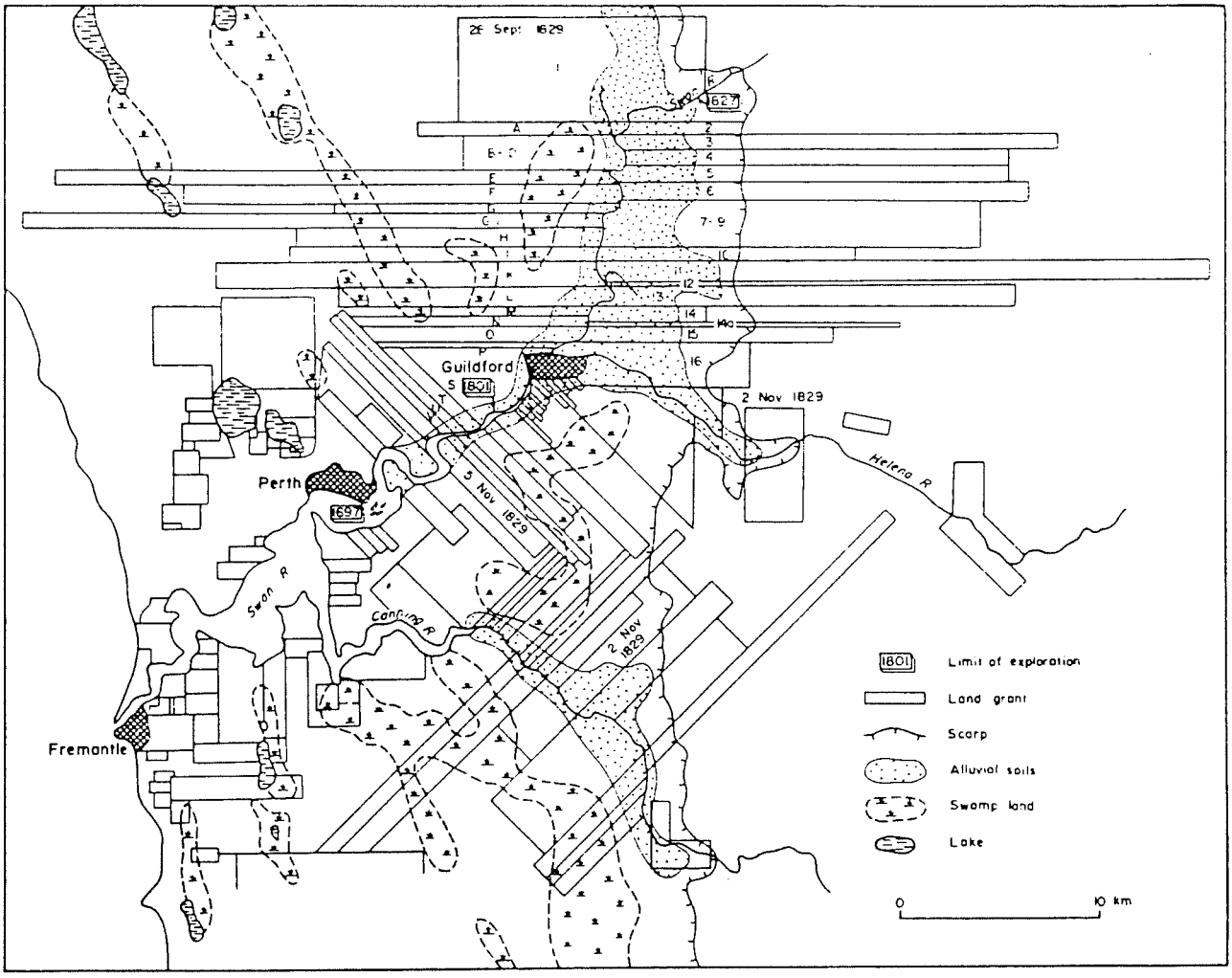


Figure 10. Early land grants on the Swan and Canning Rivers.

and Canning Rivers maximised the access of as many land-holders as possible to the scarce river floodplain soils.

Similarly, progressive plans over the decades indicate clearly that away from the main growth areas of settlement, subdivision focussed on wetlands and areas of low-lying land where organically-rich soils were to be found. The principle was to maximise access and use of the most productive land available.

Since first settlement, as land has been progressively alienated from the Crown, land ownership of many wetlands has changed. While some to this day remain in either Crown or single private ownership, the picture overall is diverse and complicated. Many wetlands illustrate highly fragmented ownership (see Figure 11). Most ironic, considering the more recent change in community attitude towards the environment and wetlands, has been the amalgamation and purchase back into public ownership of previously subdivided land. In the case of Lakes Joondalup/Goollelal this has been at the cost to date of some $8 million of taxpayers money since 1973 (estimate to February 1988 - State Planning Commission, Property Branch).

OWNERSHIP AND JURISDICTION

Private ownership of wetlands by one or several owners is fairly common, especially in rural areas of the outer metropolitan region and beyond. In this situation, the wetland is usually part of an agricultural holding. Closer into the city, joint ownership is more frequent, but single ownership by land developers also occurs.

All wetlands or parts of wetlands not in private ownership may fall into the following categories of tenure:

(a) Crown Land (vacant).
(b) State Forest land.
(c) Water Catchment Reserve.
(d) Wholly or partly contained in certain types of reserve, (including national parks).

Lentic (still water) wetlands of the coastal plain fall into all categories except (c), which only applies to the Darling Scarp.

Reserves* are set aside for a number of purposes which the Wetlands Advisory Committee summarised as follows:

(a) Drainage and Water Supply.
(b) Conservation (eg flora and fauna protection).
(c) Recreation.
(d) National Parks.
(e) Government Requirements (or public utility).
(f) Community or public use, and special purposes (other than recreation).
(g) Forestry (other than State Forest).
(h) Mining.

Footnote *'Reserve' as defined as land reserved under Section 29 of the Land Act (1933). Purposes of reserves are listed under Section 29(1).

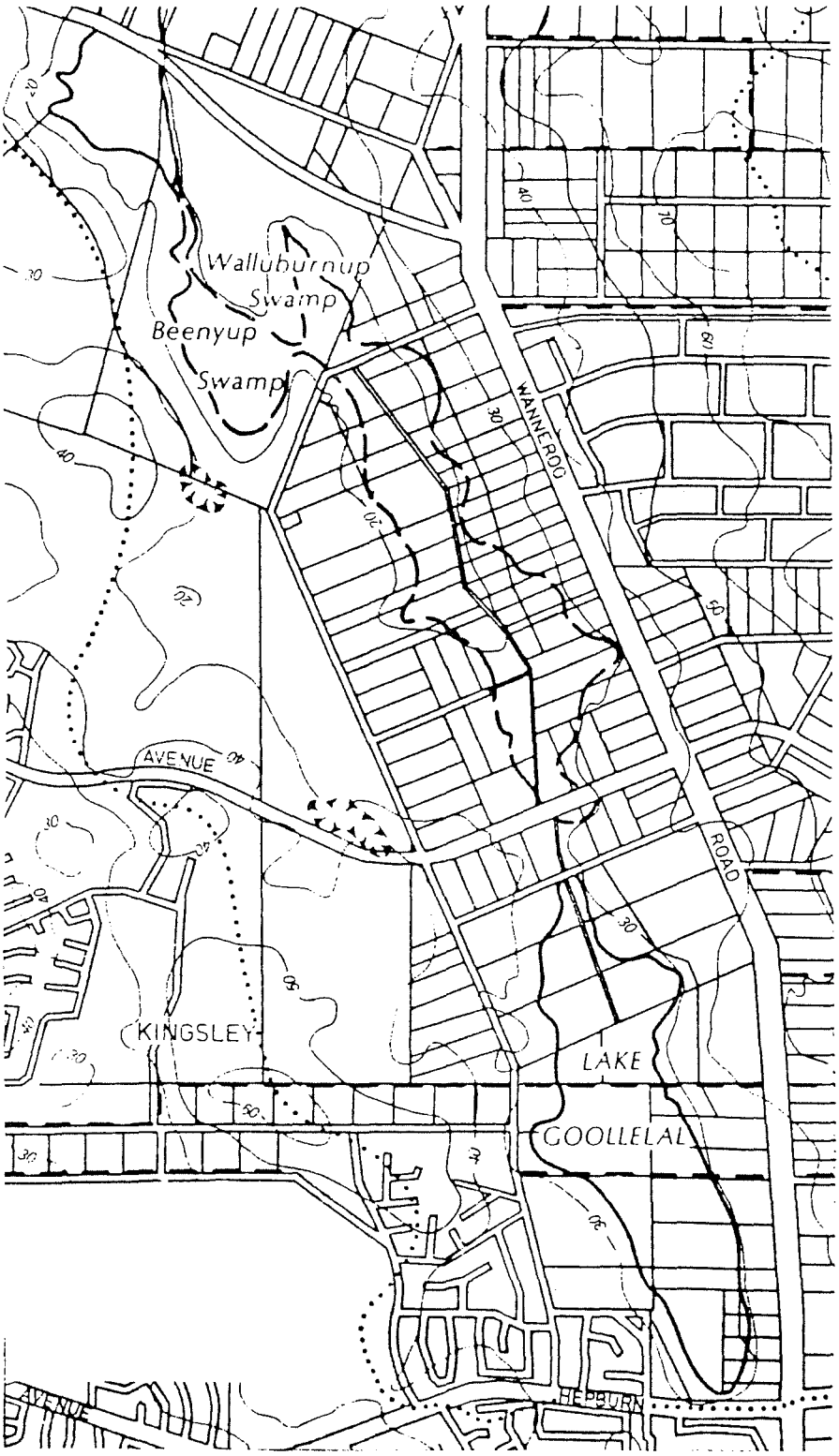


Figure 11. Lake Goollelal and Walluburnup Swamp - fragmented ownership.

They may then be put under the control of one of a number of vesting authorities, who then have statutory responsibilities in respect of the reserve to manage and control as they are able under their acts. Many of the reserves designated adjacent to or extending over all or part of a wetland are incidental to the existence of the wetland (eg cemetery, hall site, etc). Many of course, are not. In the Perth Metropolitan Region, tenure is further complicated by planning legislation which, apart from zoning controls, allows for the establishment of Parks and Recreation reserves under the Metropolitan Scheme*. This reservation is commonly referred to as 'Region Open Space' (ROS).

Parks and Recreation Reserves may cover extensive areas (eg Lake Joondalup ROS was, at first gazettal, 1619 ha), and include a variety of tenures. Some of the land may be purchased by the State Planning Commission (the former Metropolitan Region Planning Authority),in 'fee simple', while other land may be in original private ownership. Parks and Recreation reserves may also include Crown land and various types of reserve under the Land Act of 1933.

In the developed urban area or where subdivision has occurred, wetlands may also fall within 'local open space', which are recreation reserves under Local Government town planning schemes.** Smaller areas are usually involved and ownership in this situation may be held by the local authority or result from public acquisition due to conditions placed on subdivision approvals by the State Planning Commission.

Boundary designation of many reserves (Land Act) in relation to the 'natural' or physical boundary of the wetland varies considerably. Depending on prior or adjacent ownership and the purpose of the reserve, the boundary may include much more land than the wetland itself (as in national parks), just the water body, or a segment only of the wetland.

In examining reservation (Land Act) of wetlands in the metropolitan region in 1979, the following situation was found to exist in respect of conservation and recreation reserves. Taking recreation reserves first, of 123 gazetted in association with wetlands (lentic and lotic*) representing a combined area of 3 943 ha, 30 involved lentic wetlands. Of these, 3 were artificial, 8 were permanent fresh lakes (including Lakes Bibra, Jandakot, Blue Gum, Monger, Hyde Park, Gnangara, Jandalup and those in Mary Carroll Park), 4 were fresh, seasonal wetlands ranging in size from small to large (unnamed swamps), 2 were permanent brackish (Lakes Richmond and Joondalup), 1 was saline and permanent (Lake Coogee), and 3 were totally filled or drained.

Footnote * Lotic = flowing water.
** Under the Town Planning and Development Act (1928-86).

Conservation reserves gazetted in association with wetlands numbered only 15 by comparison, but representing a combined area of 4 388 ha (range 4 ha to 1 991 ha). Of these reserves, 12 involved lentic wetlands, of which 6 were permanent fresh water bodies (Lakes Blue Gum, Thompson, Jandakot/Forrestdale, Bangannup, Jandalup and those contained in Mary Carroll Park), 2 were fresh seasonal swamps (Ellen Brook reserve and Twin Swamps), 2 were brackish permanent lakes (Lakes Nowergup and Joondalup) and a remainder were unclassified due to lack of information.

Certain things are apparent from the distribution of these reserves and the types of wetland involved, as follows:

(a) There is a tendency for wetland conservation reserves to be located in the outer shires of the metropolitan area (eg Armadale-Kelmscott, Cockburn, Gosnells, Mundaring, Serpentine-Jarrahdale, Swan and especially Wanneroo).

(b) There is a tendency for wetland recreation reserves to be concentrated in inner suburbs. Many of these are modified or partially filled.

(c) Conservation reserves tend to focus on fresh or brackish permanent water, suggesting an emphasis of conservation for waterfowl habitat purposes.

(d) Almost four fifths of wetland (lotic and lentic) recreation reserves are associated with the Swan and Canning Rivers.

(e) Conservation reserves are associated with wetlands illustrating at least some modification and foreshore development, and of variable water quality.

For a more detailed assessment of wetland tenure on the coastal plain, as it relates to various wetland reservations, the reader is referred to Bulletins 59 to 62, Department of Conservation and Environment, 1979.

Practically all wetlands of the coastal plain are surface expressions of the regional groundwater body (unconfined or superficial aquifers), and as the water resources of the coastal plain are of increasing concern there are two Acts of particular relevance. These are the Metropolitan Water Supply, Drainage and Sewerage Act, and the Rights in Water and Irrigation Act. These are complex and extensive Acts, and the following are merely a few points of interest.

In Western Australia all water is vested in the Crown. Under the Rights in Water and Irrigation Act (1914), a groundwater area can be proclaimed, and the Western Australian Water Authority has the power to determine the use of all water resources therein.

This usually means a license on the use of all water, except where stock and domestic use is deliberately exempted.

Under the Rights in Water and Irrigation Act there are some interesting details. Firstly, if a person digs, constructs or scrapes a trench, hole or depression such that water appears, it is considered a well under the Act and becomes subject to the provisions of the Act. This would seem to have the potential for including artificial or ornamental wetlands that are expressions of the water table.

Under the same Act there is a standard provision in Section 6, which effectively says it is possible for a person to own a wetland (lake, swamp or lagoon) in the situation where the individual owns the property on all sides of the wetland. In such a situation the owner can do whatever he or she wants with the water. Nevertheless, there are provisions in the Act to override this when necessary.

Finally, it is worth noting references to offences under the Rights in Water and Irrigation Act. In Section 25 it says that it is an offence "under this or any other Act to obstruct, destroy or interfere with the waters, beds or banks of any water course flowing through or over, or lake, lagoon, swamp or marsh situated wholly or partly on land that is being granted or demised by the Crown".

SPECIFIC EXAMPLES - TENURE PATTERNS

The pattern of tenure which eventually establishes over a wetland can produce some odd results, which have practical implications. The following examples are included to give those readers who may not have had experience in dealing with tenure over wetlands some feeling for what may arise.

LAKE JANDABUP

Lake Jandabup is a good example of large shallow wetland with fragmented subdivision around the edge, and the main body of the wetland remaining in a larger unit, (reserve 7349 for Conservation of Fauna).

Figure 12 shows how an original Lot (1635), at the southern end, when subdivided produced a further area of open space to add to the existing reserve 33193 for public recreation. This was to bring private ownership further back from the existing wetland edge.

In the area of location 1686 (south west corner of the lake) can be seen a battle-axe block lot 1, behind Lot 15. On the lake side of lot 1 is a further small lot 2 which was almost certainly given up free of cost to the Crown as a condition of approval on the battle-axe subdivision. Notice how the alignment 'shadows' the edge of the lake body. It indicates the commencement of a long-term objective to gain a sufficient publicly-owned 'set-back' around the perimeter of the lake body, the opportunity being taken whenever a subdivision proposal arises.

Larger original holdings in the north west and north east sectors of the lake (locations 1655, 1504 and 5205) have also been subdivided. In these cases, the planning authorities required that between 40 and 50 percent of the land area of the holdings be given over for 'open space' purposes. In these examples, the then Minister decreed that the land need not be given free of charge, but should be acquired in due course by the 'appropriate authority'.

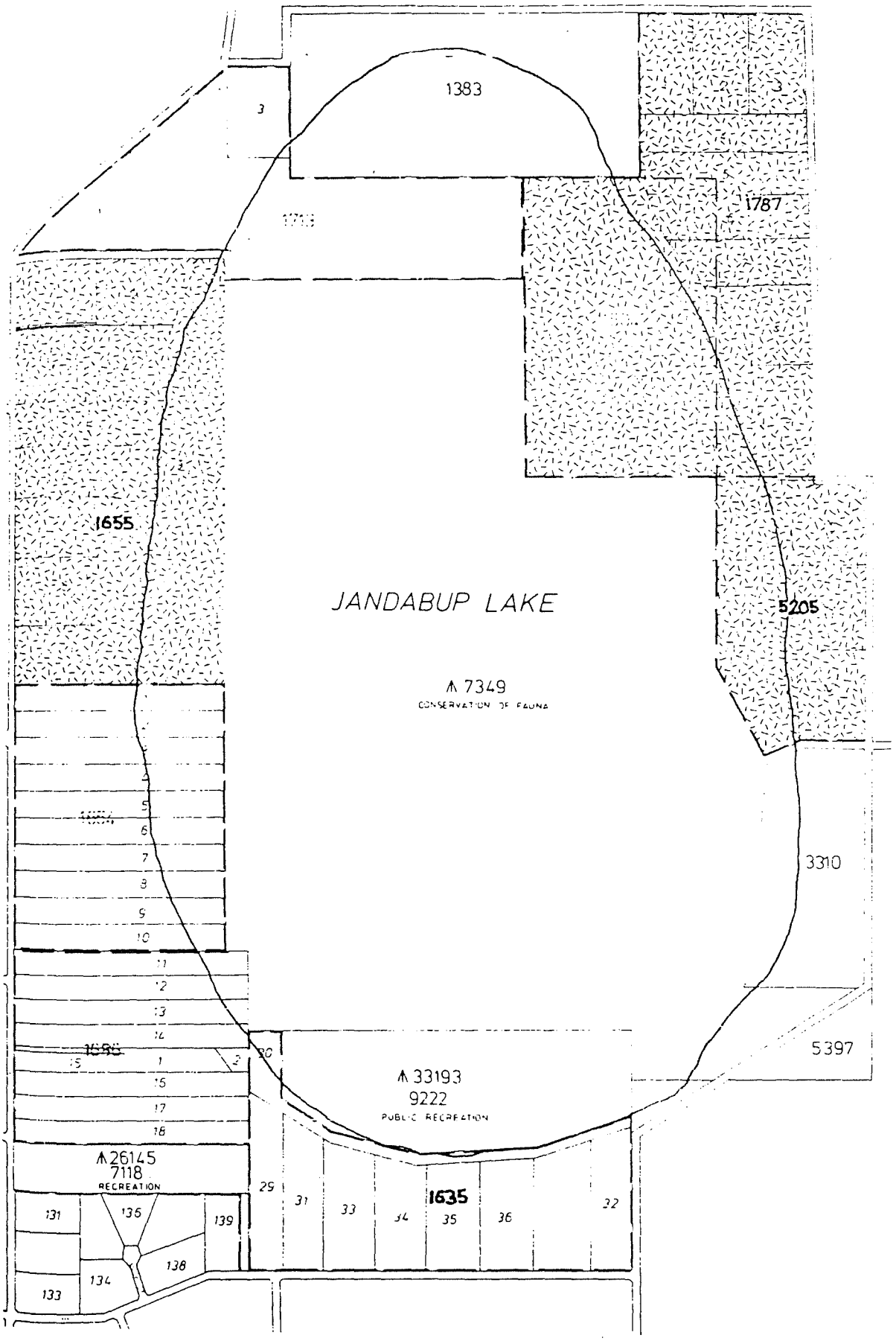


Figure 12. Subdivision patterns - Lake Jandabup.

LAKE JOONDALUP

In the early days, the eastern shore of Lake Joondalup was subdivided to create the township of Wanneroo. The balance of the lake remained in public ownership and in due course became an 'A' class reserve for the purpose of recreation and the conservation of flora and fauna. The odd and somewhat absurd result is that an 'A' class reserve with stringent intent to protect the environment has much of its eastern boundary within the lake body. Most of the rest of the reserve boundary is at the water's edge. As such,it also fails to include perhaps the most important ecological zone of any natural wetland, the zone of fringing vegetation and an adequate buffer to secure the immediate peripheral dry-ground vegetation.

In the case of Lake Joondalup, the entire wetland system is now contained within a reserve for parks and recreation under the Metropolitan Region Scheme. To secure it as a major park in public ownership that will be manageable, public acquisition of the private land component has been continuing since 1973. However, as can be seen in Figure 13, and as mentioned earlier, fragmented and varying forms of tenure have not made this easy.

The Joondalup Region Open Space (ROS) area is indeed an excellent example of the diverse terms that can occur. Figure 13 illustrates portions in private ownership, MRPA (now State Planning Commission) ownership, vacant Crown Land and Crown vested in the Shire, and Crown Land jointly vested in the local authority and a state agency.

The Joondalup ROS area also illustrates some good examples of practical management implications resulting from a poorly devised arrangement of tenure. Lake Goollelal at the southern end of the Joondalup ROS area, also features fragmented ownership. Figure 14 illustrates not only this but a curious alignment of the Metropolitan Region Scheme reserve boundary, whereby in the south west corner the reserve boundary swings back into the lake body itself, clearly to avoid the inclusion of part of five lots fronting onto Wanneroo Road. Figure 15 indicates the land is zoned 'Urban' in the Metropolitan Region Scheme, and indeed the land use of some of these lots is commercial. One is (or was) a commercial retail nursery.

On the basis of these facts, it is interesting to note the pattern of vegetation at Lake Goollelal which clearly indicates an outbreak of the aquatic weed Water Hyacinth concentrated in the southern portion of the lake body. This outbreak had to be brought under control quickly by extensive chemical spraying, and the programme cost many thousands of dollars. Although there is no proof of where the Water Hyacinth came from, or how it entered the lake, one could be forgiven for supposing it had something to do with the existance of the commercial nursery, the rear boundary of which was at the waters edge. Site inspection in 1978 revealed a number of 'colourful' exotics establishing at the waters edge, obviously originating from the nursery itself.

Here then is a clear example of management implications arising from an inappropriate arrangement of tenure, and inadequate set-back. Given the Urban zoning of this portion of land, one can only guess at the adverse pressures that will be placed on this small but attractive wetland when future redevelopment occurs.

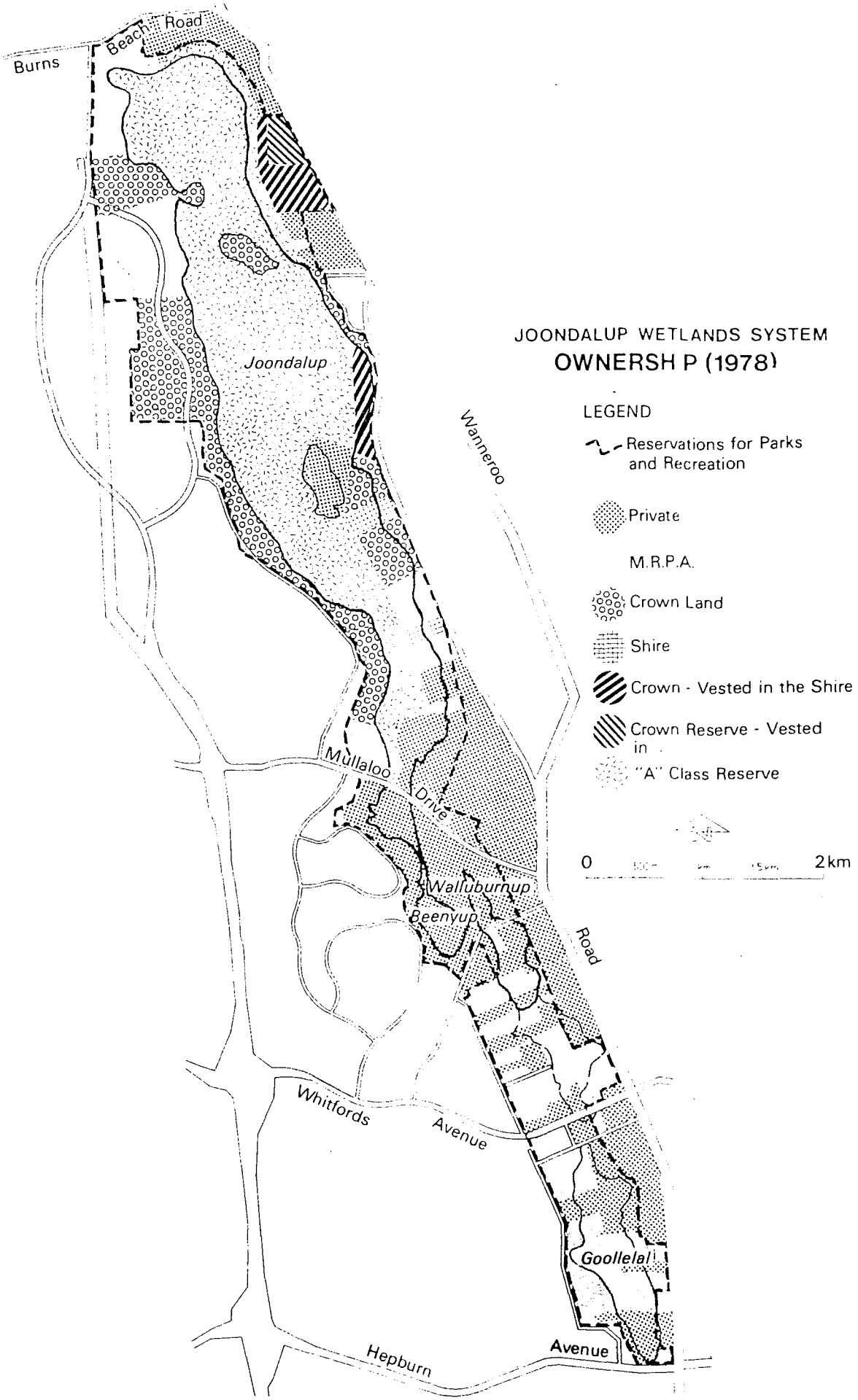


Figure 13. Lake Joondalup : ownership 1978

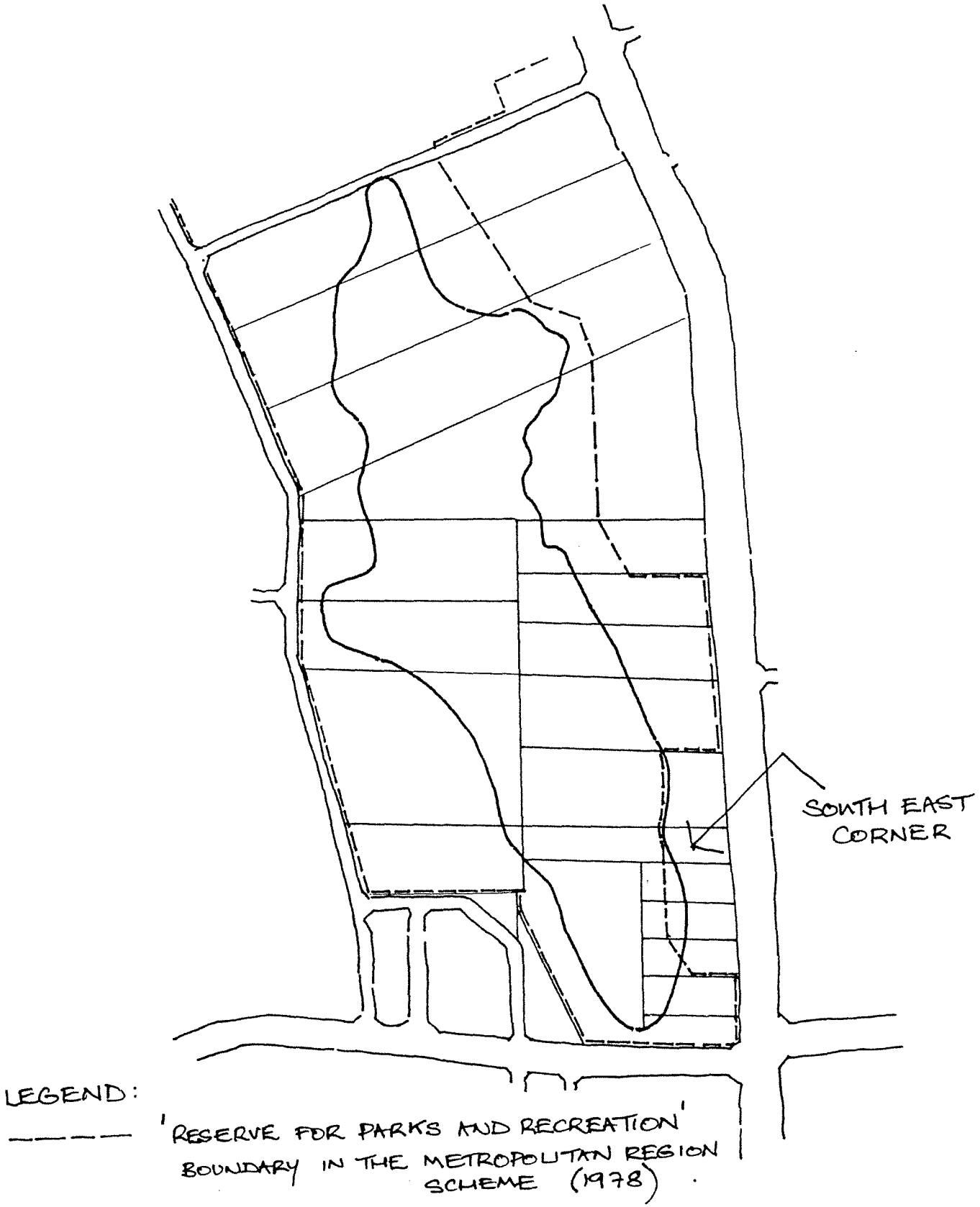


Figure 14. Lake Goollelal - subdivision pattern (1979).

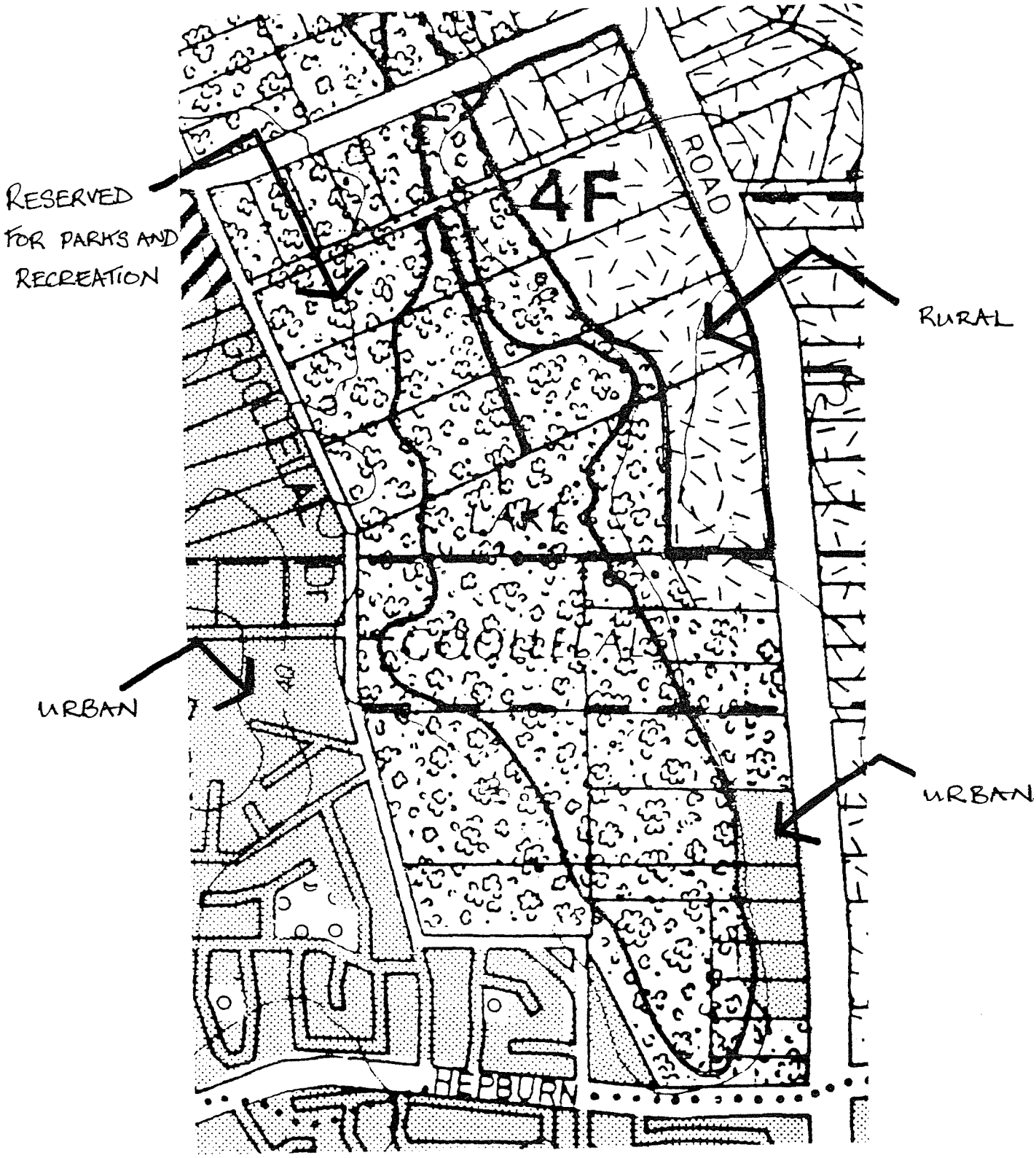


Figure 15. Lake Goollelal - Metropolitan Region Scheme zoning (1978)

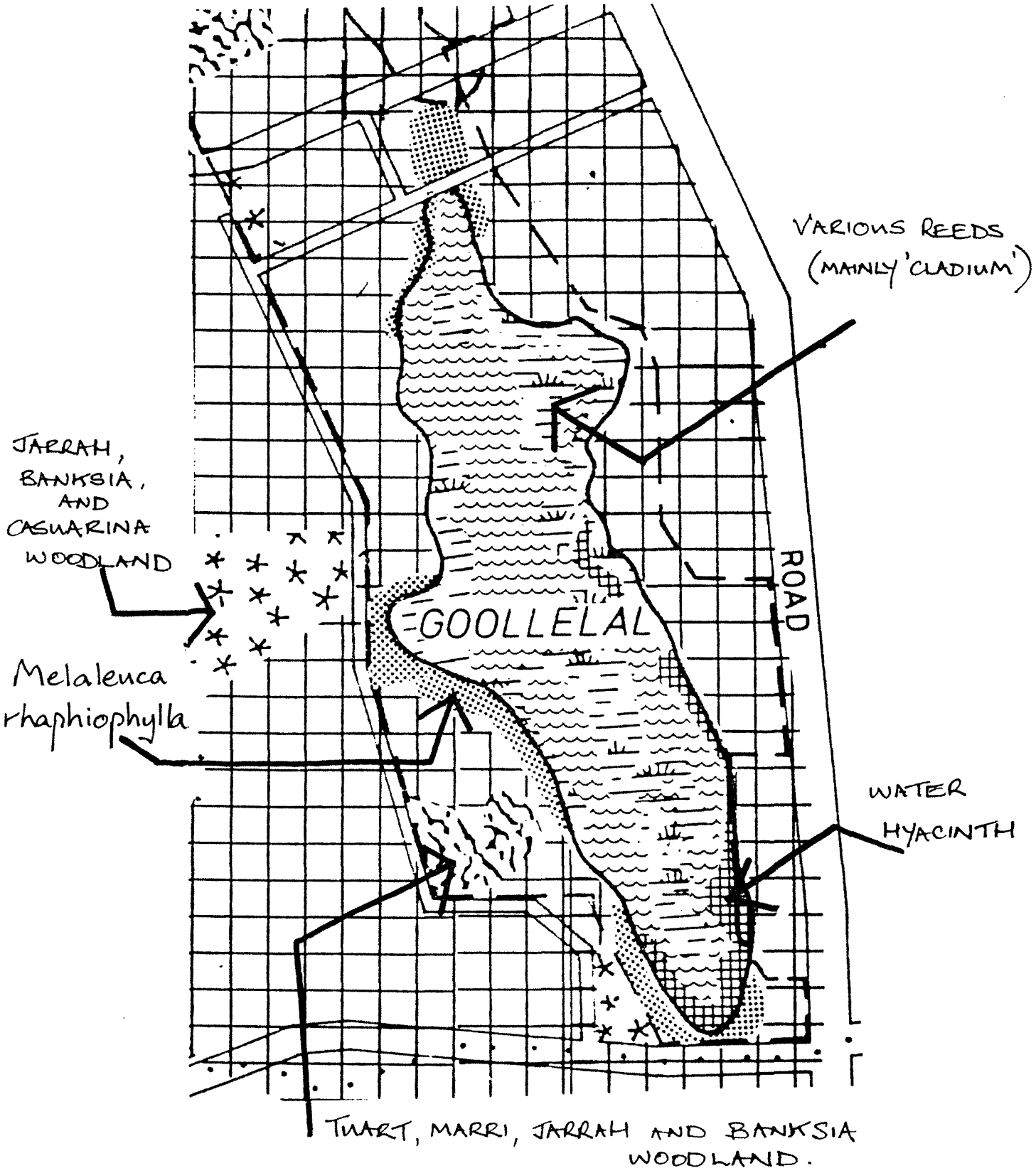


Figure 16. Lake Goollelal - Vegetation (1978).

LIMITED MODEL FOR WETLAND SUBDIVISION

While it is difficult to generalise, the question inevitably arises as to what basic principles should be applied by designers and decision-makers in considering changes in tenure of any given wetland.

Historical patterns of subdivision will to a degree dictate the options available, as will the financial ability of the community (or government agency) to acquire land in private ownership.

Nevertheless, certain basic rules should apply in devising the best possible tenure arrangements. In the situation of setting aside a wetland in a reserve, say at the time of a major subdivision, the following guidelines should apply (see also Figure 17):

- attempt to secure a single ownership over the entire wetland and its surrounds;

- include any minor wetland outliers that may be ecologically or hydrologically connected;

- in devising a boundary around a wetland, ensure all wetland vegetation is included*;

- take account of the direction of regional groundwater flow, and if possible, the hydrological gradient also (rate of flow), by providing a greater set-back to future land developments on the "up-stream" side of the wetland system; this should help reduce interference of water levels resulting from private bore abstraction, contamination from septic tanks, and general nutrient enrichment from 'up-stream' land use activities;

- ensure an adequate buffer area around the entire wetland, not only to secure wetland vegetation, but to allow functional (user and management) linkages around the wetland (ie access tracks, footpaths and trails, service/infra-structure alignments for reticulation and power);

- if, as is often the case, there are important associated landscape features such as adjacent hillside, ridge-line, limestone outcrops or stands of vegetation then, if possible, include these in the re-arrangement of tenure;

- where adjacent rural subdivision or subdivision to large lots size occurs, the lots created should have 'building envelopes' designated that ensure leach drains and septic tanks are at a maximum distance away from the wetland, and care should be taken to avoid the possibility of local subsurface drainage and surface runoff from adjacent developments entering the wetland;

Footnote *Subtle changes in vegetation type occur as water and soil moisture conditions change, often giving rise to concentric patterns of vegetation type and texture around the margins of the wetland that can be easily identified in air photos. These "ecotones" indicate, in particular, the important peripheral vegetation that is an essential buffer to a biologically healthy wetland.

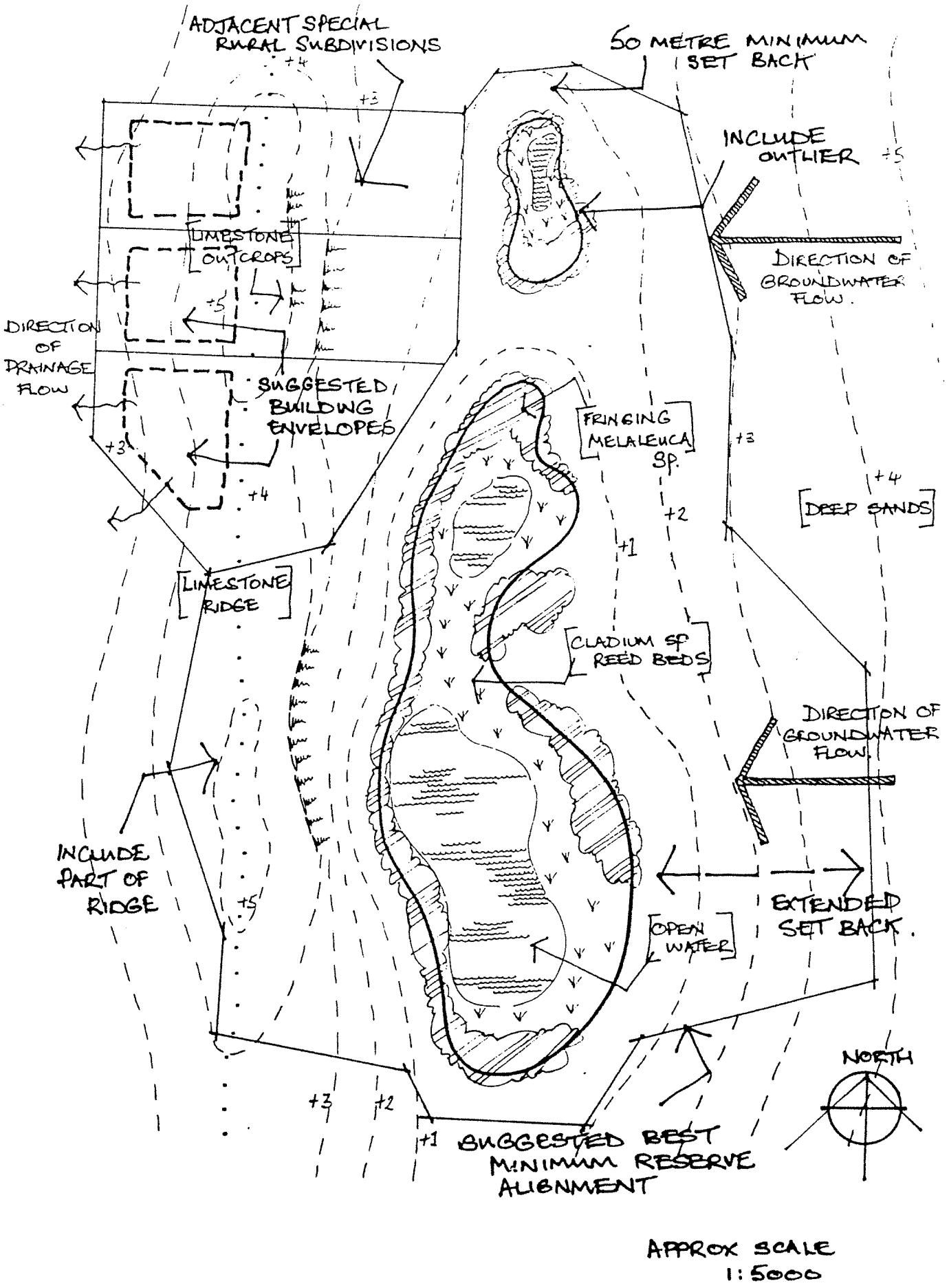


Figure 17. Theoretical subdivision for typical wetland.

- should it be unavoidable that disposal of surface runoff from adjacent developments be diverted to a wetland reserve, then tenure should be arranged to allow for a sufficient area adjacent to the wetland body for disposal of runoff and stormwater into an artificially excavated and well-vegetated 'receiver' wetland, specifically designed for the purpose; and

- attempt to secure road reserve frontages to publicly-owned park or reserve tenure over wetland environments, as these assist with management and the encouragement of responsible community attitudes to the wetland itself.

These guidelines are only a starting point to devising a sensible pattern of subdivision and tenure for any wetland, and are most applicable to wetlands in a rural or semi-rural context where adjacent land use is changing and intensifying. Many other actions and factors will also contribute to the best long-term control and management of a wetland.

CONCLUSION

This paper has attempted to cover the history of human habitation and settlement on the coastal plain as it has been influenced by and has in turn affected wetlands. Patterns of tenure are one outcome of human exploitation or avoidance of wetlands. It is argued here that such patterns, which have great practical implications for subsequent wetland management are the end product of cultural practices (methods and techniques of ownership), societal perception of the environment (empathy or hostility), and society's exploitive tendencies and preferences.

The challenge of safeguarding and best using the stock of wetland resources on the coastal plain will be greatly assisted by ensuring that the tenure of wetlands is always arranged to be as simple as possible (single ownership) and extensive enough to ensure adequate setbacks and buffers to adjacent development.

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PROBLEMS: CAUSES, CONSEQUENCES AND CORRECTIVES

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ABSTRACT

The most obvious problems of Perth's urban and near-urban wetlands are caused by the excessive availability of the major plant nutrients, phosphorus and nitrogen.

Such excessive nutrient availability results in a variety of symptoms, including:

- algal blooms, with consequent shoreline fouling and decomposition odours;
- excessive growths of water weeds including the rush *Typha* spp.;
- plagues of non-biting midges, and in some cases mosquitoes;
- waterfowl deaths; and
- loss of valuable wetland habitat, wetland biota and aesthetic and recreational value for people.

In addition to excess nutrients, wetlands may be damaged by altered water regimes, inflow of polluted ground and surface waters, including urban and road runoff, rubbish tip leachate, agricultural drainage waters, and inadvertant chemical spills, and by deliberate application of pesticides, filling, modification or alienation. Most of the above problems result from ignorance of wetland processes, and ignorance of the consequences of altering these processes.

The consequences of such deleterious changes are diverse, and include:

- diminished environmental quality and reduction of public amenity;
- loss of wildlife habitat at local and regional scales;
- complaints to local and state government authorities, and sometimes political agitation for remedial action;
- administrative and technical difficulties in managing wetlands; and
- high public costs of wetland restoration and on-going management.

The solutions to these problems are not easy, and in some cases management may not be technically possible. However, much can be done, including:

- reduce nutrient inputs to wetlands, reduce nutrient storage within wetlands or increase nutrient export from wetlands;
- develop biologically "soft" pest control measures, and minimise pesticide applications;
- develop better urban design and drainage strategies;
- instigate better land-use planning and management practices;
- continue investigation of cost-effective technical remedies for damaged wetlands;
- engender public awareness of, responsibility for and participation in wetland management; and
- confront and deal with the administrative and financial constraints to good wetland management, and clarify the definitions of responsibility for wetland management.

WETLAND FUNCTION

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ABSTRACT

The shallow permanent and seasonal wetlands of the Swan Coastal Plain are surface expressions of the underlying groundwater and water levels vary with the height of the water table.

Groundwater is an important water resource in the Perth region and the wetlands are part of this resource. The wetlands are also valued for wildlife conservation and as areas of open space within the city. A knowledge of wetland function and wetland processes is vital for the appropriate management of Perth's wetlands.

The wetlands are areas of high biological productivity and directly or indirectly support most of the wildlife of the Swan Coastal Plain. Their importance for wildlife conservation also extends beyond the coastal plain as they are visited by migratory wading birds from the northern hemisphere and by water-birds which move to the coastal area when inland water bodies dry during summer.

Wetland plant communities are central to all wetland processes. They provide a range of habitats for aquatic and terrestrial fauna and constitute the primary production that is the basis of all wetland food-webs. Waterbirds are the most conspicuous members of wetland foodwebs but aquatic macroinvertebrates are also important and responsible for a significant proportion of the secondary production occurring in wetlands. The macroinvertebrate fauna forms two interconnected wetland food chains: a grazing food chain and a detrital food chain.

Excessive nutrient enrichment or eutrophication is a major problem in many urban wetlands and the presence of excess nutrients results in greatly altered food webs. Massive algal blooms occur in spring and summer with attendant odour problems and bird deaths. Detrital food chains are enhanced by the presence of increased organic matter (which results when the algal blooms decay) and the result may often be the occurrence of nuisance swarms of midges. Pesticides and exotic fauna (in particular the mosquito fish, *Gambusia affinis)* may also serve to indirectly reduce water quality through alterations to invertebrate food chains.

Too much or too little water also disrupts wetland ecosystems. Because they are shallow waterbodies (depth <3m), long-term changes in watertable elevation from the normal seasonal variations may present a serious stress to wetland ecosystems. Successive dry years and overpumping of groundwater may result in some wetlands having too little water to support aquatic flora and fauna. Other wetlands may receive too much water from increased urban runoff, leading to increased depth and a loss of seasonality.

Wetland ecosystems appear to be quite resilient. Much of the flora and fauna is adapted to withstand the stresses of drying and filling and many mechanisms for recolonizing waterbodies appear to exist. These factors indicate that degraded wetlands with poor water quality can be rehabilitated with appropriate catchment and in-lake management. However it is important that all the possible effects of a management action on wetland processes are known, and considered acceptable, before any action is undertaken.

INTRODUCTION

The wetlands of the Swan Coastal Plain are areas of high biological productivity and directly or indirectly support most of the wildlife of the coastal region. In addition to providing an immense habitat resource for the local fauna they are also of regional and international importance. The wetlands are visited by waterbirds which move to the coastal areas when inland waterbodies dry during summer and by migratory wading birds from the northern hemisphere. The wetlands are valued not only for wildlife conservation however, but also have considerable recreational and aesthetic value as distinctive landscape features within the urban environment. The values which the communities of Perth place on the urban wetlands indicates that a high priority must be given to the proper management of these areas. This requires a knowledge of how wetlands function and involves an understanding of the physical, chemical and biological processes that occur within these waterbodies.

HYDROLOGY

The shallow permanent and seasonal wetlands of the Swan Coastal Plain are surface expressions of the underlying aquifer, and as such, a part of the region's groundwater resource. This resource, however, not only sustains wetland ecosystems but it also provides water for a wide variety of human activities on the Swan Coastal Plain.

Water levels in the wetlands vary according to the height of the water table and because the region has a mediterranean climate with cool wet winters and hot dry summers, the wetlands experience a strongly seasonal hydrological cycle. The aquifer is recharged by winter rains and wetland water levels rise. During summer, the wetlands act as evaporating basins and water levels fall (Fig. 1). A comparison of monthly rainfall totals for Perth over the period April 1985 to June 1987 (Fig. 2) and water level records for two lakes, Lake Monger and Thomsons Lake (Fig. 3), clearly reveals that wetland water levels do follow the pattern of rainfall but with a lag of approximately two months. Maximum depths occur at the end of winter in September and October. The lowest water levels or complete drying occurs at the end of summer in March and April.

The urbanisation of the Perth region has led to changes in both the quality and quantity of the surface water and groundwater inputs to wetlands. Many of the wetlands act as compensating basins within local drainage systems and receive runoff from drains that may extend some distance into the surrounding catchment. As a consequence, many wetlands now receive a considerably greater proportion of their water from surface inputs than they did in the past. Water levels have risen in some wetlands as a result of increased runoff from paved areas (houses, roads, pathways, etc.) and much of the seasonality of the hydrological regime has been lost. However, other wetlands may be in danger of having too little water to sustain aquatic life as a result of overpumping of groundwater for domestic and horticultural water supply.

Both the wetlands illustrated here, Lake Monger and Thomsons Lake, showed strong seasonal changes in depth, although Thomsons Lake dried completely each summer, while Lake Monger contained permanent water (water is pumped into Lake Monger during the summer months to prevent drying).

WATER CHEMISTRY

Perth's climate and the seasonality of the hydrological cycle has important implications for the water chemistry of the wetlands. Most of the wetlands within the Perth region are fresh but the concentration of salts can rise during the summer months as a result of evaporative concentration. This effect is most evident in the seasonal wetlands. Conductivities rose to levels that are considered to be brackish or saline in Thomsons Lake just before it dried each summer (Fig. 4), whilst conductivities recorded at Lake Monger were fairly constant and the lake remained fresh throughout the year.

The concentration of nutrients also rises during summer as a result of evaporative processes and again this effect is most evident in seasonal wetlands such as Thomsons Lake (Fig. 5). In addition, however, nutrient levels can be expected to rise in wetlands during the summer months as a result of the increased biological activity that occurs during this time in response to higher water temperatures and increased light availability. Many of the wetlands in the Perth region receive large amounts of nutrients in the surface waters entering through drains and in this situation the "first flush" of water that enters wetlands at the start of the winter rains may have a significant effect on water quality. The excessive nutrient enrichment that has occurred in some lakes within the urban area is illustrated by the amounts of total phosphorus (P) recorded on a monthly basis at Lake Monger over the two year period 1985 to 1987 (Fig. 5). Peaks of 700-800 ug/l of total P are well above the levels of 30 ug/l and 100 ug/l set for eutrophic and hypereutrophic systems respectively. The result of this enrichment is often excessive algal growth. A comparison of the levels of chlorophyll *a* in Lake Monger with those in Thomsons Lake (chlorophyll *a* is used here as a measure of the amount of algae in the water column) (Fig. 6) reveals that Lake Monger experiences excessive algal growth for much of each year, whilst algal production in Thomsons Lake is low.

WETLAND FOOD WEBS

PRIMARY PRODUCTION

Wetland plant communities are central to all wetland processes. They represent the primary production that forms the basis of all wetland food webs. The reeds and rushes that comprise the fringing vegetation and the submerged macrophytes of the lake proper provide both food and shelter for the waterfowl, tortoises, frogs, invertebrates and other animals that comprise the faunal component of the wetland system. Algal cells form an important part of the diet of many of the invertbrates, particularly the zooplankton, which in turn are consumed by other wetland animals. How does excessive algal growth affect a wetland ecosystem when the presence of some algae is necessary to the proper functioning of the wetland? As a lake becomes enriched, there is a change in the composition of the lake's plant communities from submerged aquatic plants to green algae to blue-green algae.

Blue-green algae are toxic to many animals and the presence of large blooms of blue-green algae in a lake indicates a considerable degradation in the function of that system. The presence of such blooms may be enhanced not only by the input of excessive nutrients into a lake but actions such as the removal of the fringing vegetation and wetland deepening. The fringing reeds and rushes take up large quantities of nutrients from the lake waters and so their removal will result in a greater availability of nutrient for algal growth. Most of the aquatic macrophytes which occur in Perth wetlands require fairly shallow waters for their growth and so the depending of a wetland by dredging may change a wetland from a macrophytic system to one dominated by algae.

SECONDARY PRODUCTION

Waterbirds are the most conspicuous members of wetland food webs but aquatic invertebrates are also important and are responsible for a significant proportion of the secondary production occurring in wetlands. The invertebrate fauna forms two interconnected wetland food chains; a grazing food chain and a detrital food chain (Fig. 7). The grazing chain comprises those organisms which feed on algal cells or aquatic plants, and these in turn are fed upon by other animals, the second order consumers or predators. Grazing organisms include many of the microcrustaceans which make up the zooplankton, such as Daphnia (the waterflea) and aquatic snails. The detrital food chain comprises those animals which feed on dead and decaying plant and animal material. Perhaps the most well known detrital feeder of Perth wetlands is the larval chironomid or midge. Chironomids complete their larval cycle within the lake to emerge during the summer months as small non-biting flies that form nuisance swarms in nearby suburbs. Other detritivores include several crustacean groups; the ostracods, amphipods and phreatoicids, the aquatic oligochaetes (the worms) and insects such as the mayflies and caddisflies. Predatory invertebrates include the damselflies and dragonflies, aquatic beetles and bugs, water mites andflatworms.

Both food chains play important roles in the functioning of wetlands ecosystems. The grazers maintain good water quality by feeding upon algae while the detritivores process the decaying organic matter of the lake bed.

CONSEQUENCES OF ALTERING WETLAND FOOD WEBS

Recent studies by the Wetland Ecology group at Murdoch have revealed that food webs may have become greatly altered in some urbanised wetlands. As a very approximate rule, the numbers of invertebrate species present in a wetland appears to decrease as a lake becomes more urbanised (Fig. 8). Detrital food chains become increasingly dominant and many invertebrate predators may be absent from excessively enriched or polluted lakes.

As noted above, grazing organisms such as Daphnia play an important role in maintaining good water quality within a wetland by feeding upon suspended algal cells. However, when algal blooms become very large as a result of the presence of excessive nutrients or they are comprised of toxic species, such as the blue-green algae Microcystis and Anabaena, the numbers of grazing organisms will be insufficient to process all the algal material and to reduce the blooms to tolerable levels.

As the blooms die off and decompose, offensive odours may result and oxygen levels within a lake may become seriously depleted as a result of intensive microbial action. Decomposing algal blooms provide a large food source for detritivores and the growth of larval midges is particularly favoured. As a consequence, the management of midge problems at a wetland must involve some treatment of the cause of the problem; the entry of excessive nutrients into the lake and the resultant algal blooms. The presence of pollutants, such as pesticides and the introduced mosquitofish, Gambusia affinis, can also result in poor water quality through their effects on wetland food chains. Many grazing organisms such as Daphnia, are particularly susceptible to pesticides. These larger members of the zooplankton may also be selectively grazed by the mosquitofish. Both impacts will result in a decrease in the numbers of grazers and, as a consequence, the capacity of the wetland to process algal blooms will be diminished. Pesticides, toxic algae, and low oxygen levels may also result in the death of the larger predatory invertegrates such as larval dragonflies and beetles. Invertebrate predators are often an effective means of control of nuisance organisms such as larval midges, and so their absence from a wetland may result in greater problems with nuisance midge swarms than would otherwise occur.

CONCLUSIONS

These examples indicate why a knowledge of wetland functions and processes is vital for the effective management of Perth's wetlands. Wetland food chains can be altered by the poor quality of the water which a wetland receives and these alterations in turn will result in problems of algal blooms and nuisance swarms of midges. The poor quality of drainage water and groundwater in some areas indicates that, in many instances, wetland problems need to be tackled at the catchment level and the regional level rather than treating the lake as an isolated water body.

On the positive side, wetland ecosystems appear to be quite resilient systems. Much of the flora and fauna is adapted to withstand the stresses of seasonal changes in water levels and water chemistry and many mechanisms for the recolonisation of waterbodies appear to exist. These factors indicate that degraded wetlands with poor water quality can be rehabilitated with appropriate catchment and in-lake management. However, it is important that the probable effects of a management action on all components of a wetland system are known, and considered acceptable, before any action is implemented.

ACKNOWLEDGEMENTS

Colleen Hubbard is thanked for the typing of several drafts of this manuscript and Steve Rolls for the preparation of the diagrams.

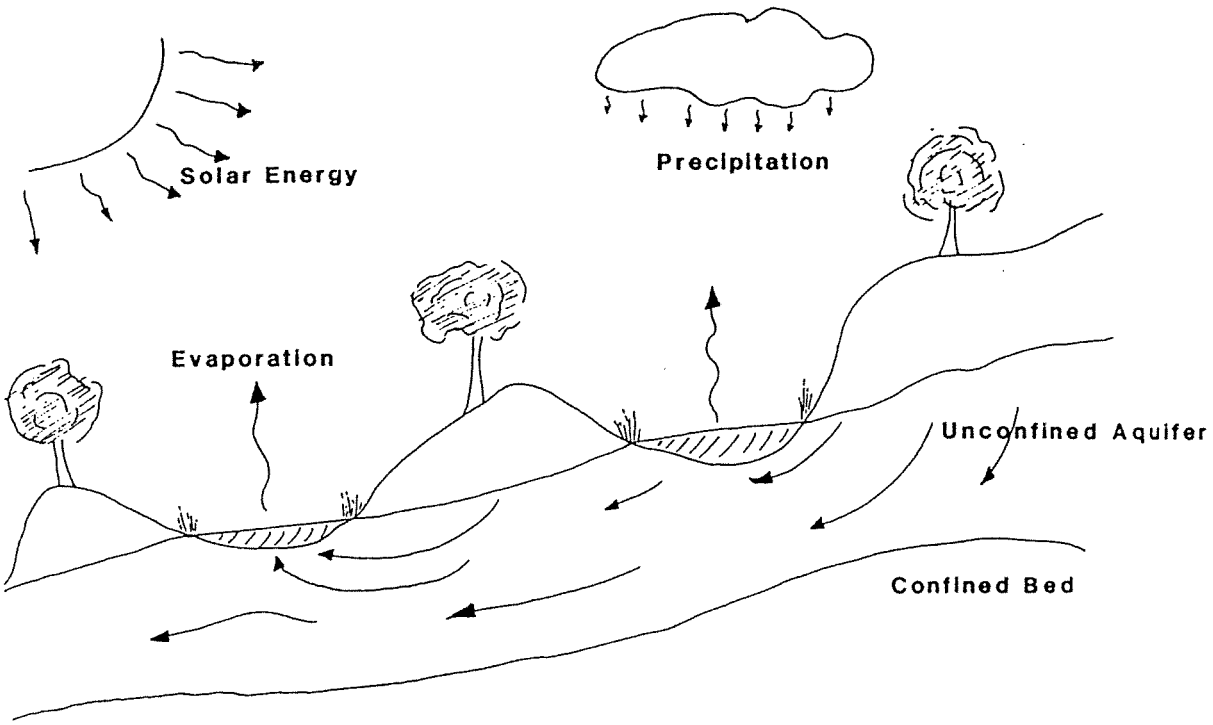


Figure 1. Diagrammatic summary of the seasonal hydrologic cycle experienced by wetlands on the Swan Coastal Plain.

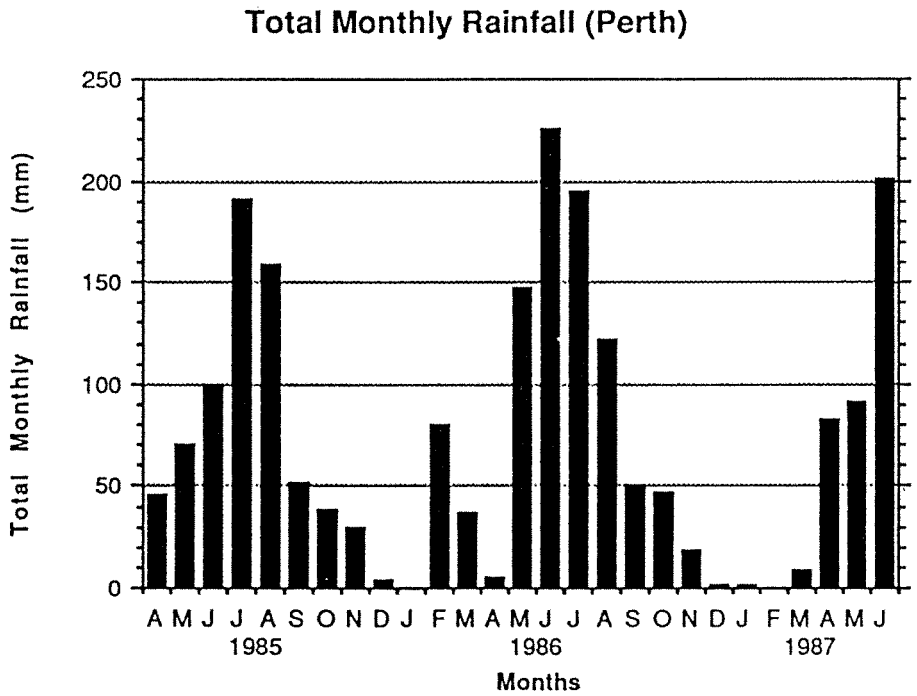


Figure 2. Monthly rainfall totals (in mm) for Perth for the period April 1985 to June 1987.

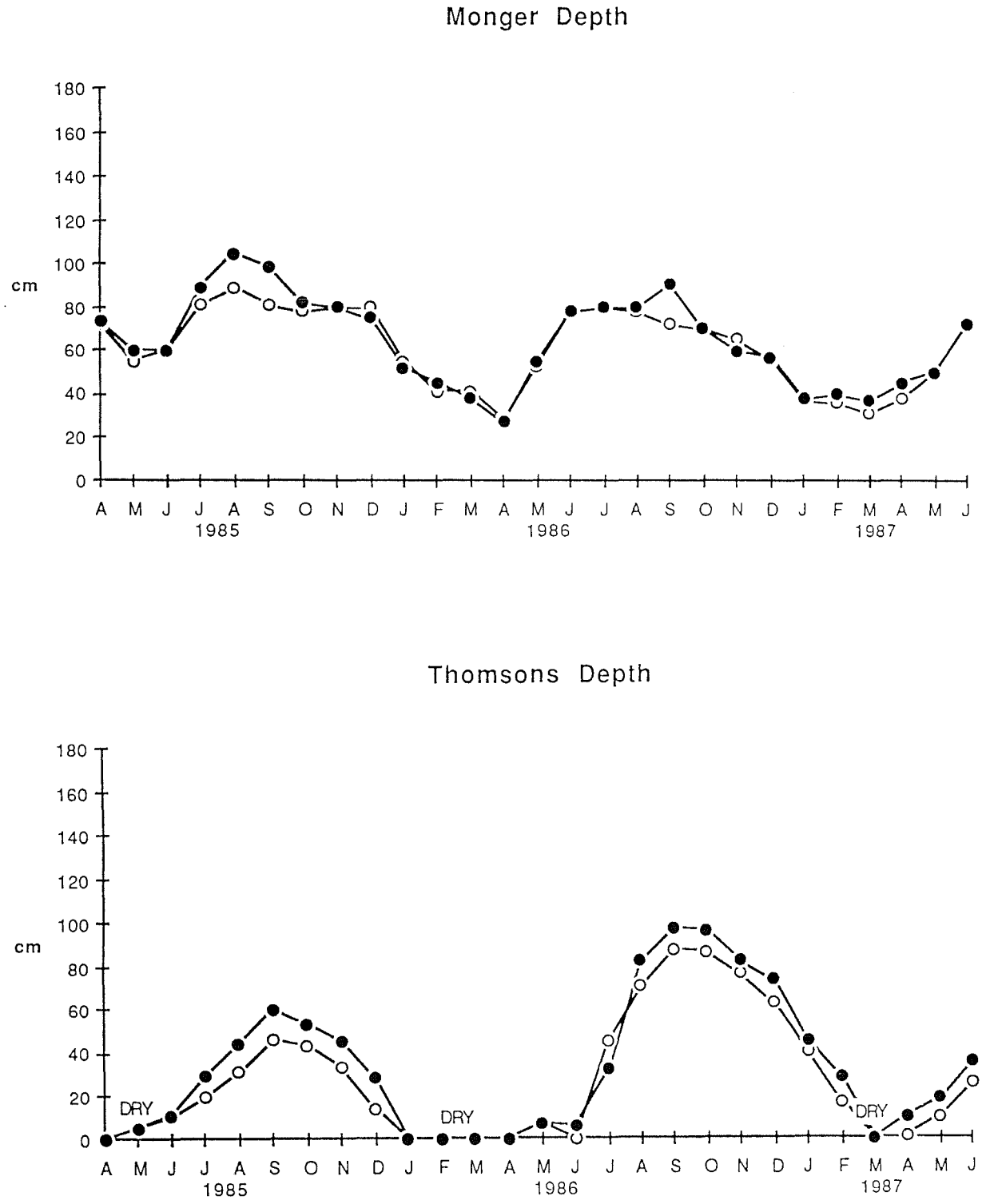
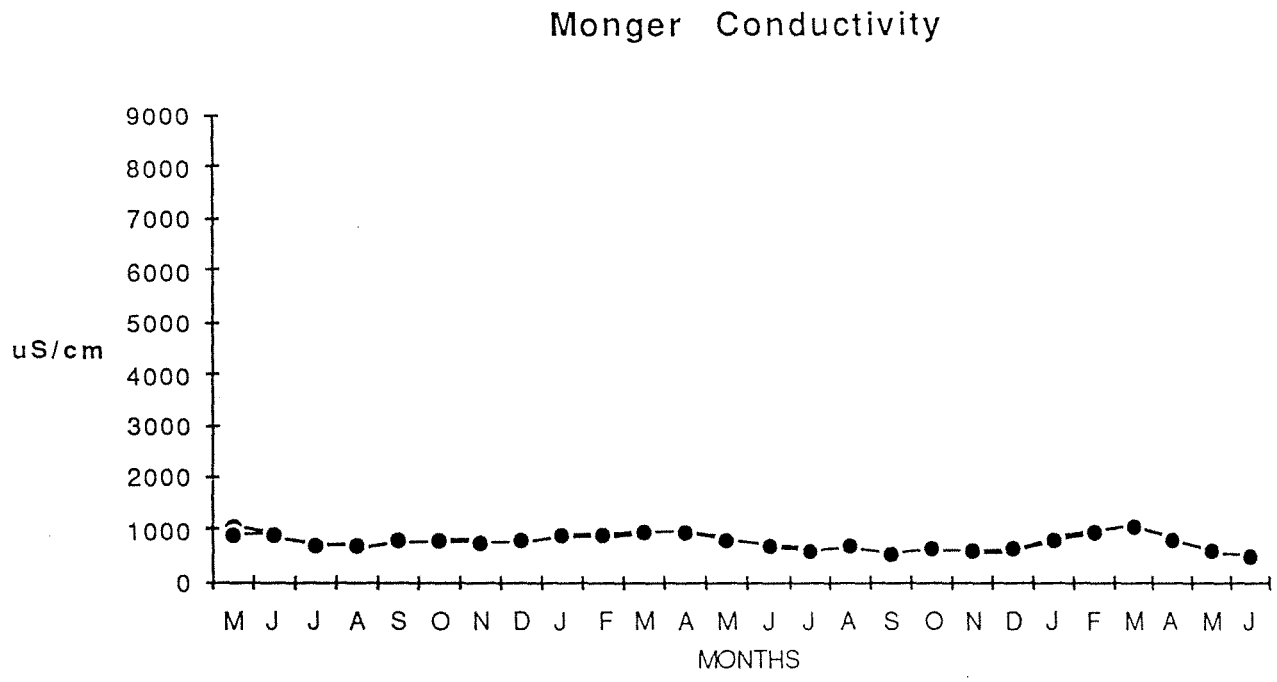


Figure 3. Monthly changes in depths over the period April 1985 to June 1987 at two sites in Lake Monger and Thomsons Lake.



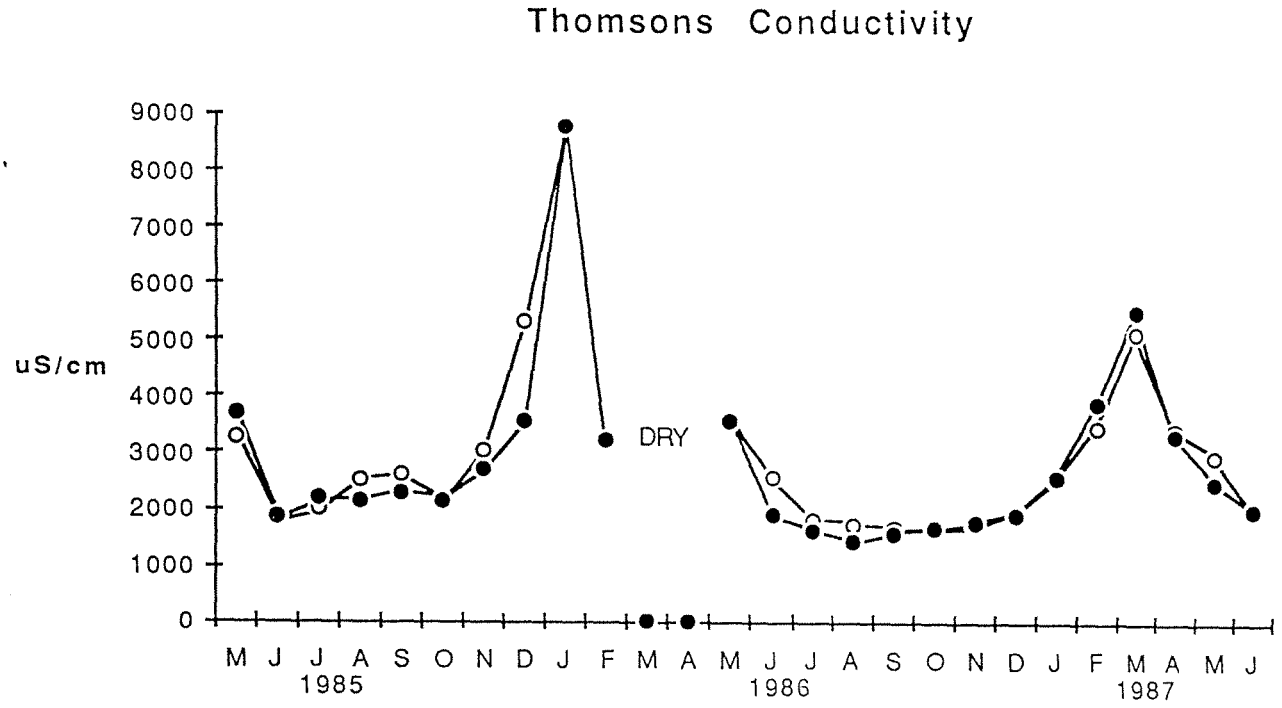


Figure 4. Monthly changes in conductivity over the period May 1985 to June 1987 at two sites in Lake Monger and Thomsons Lake.

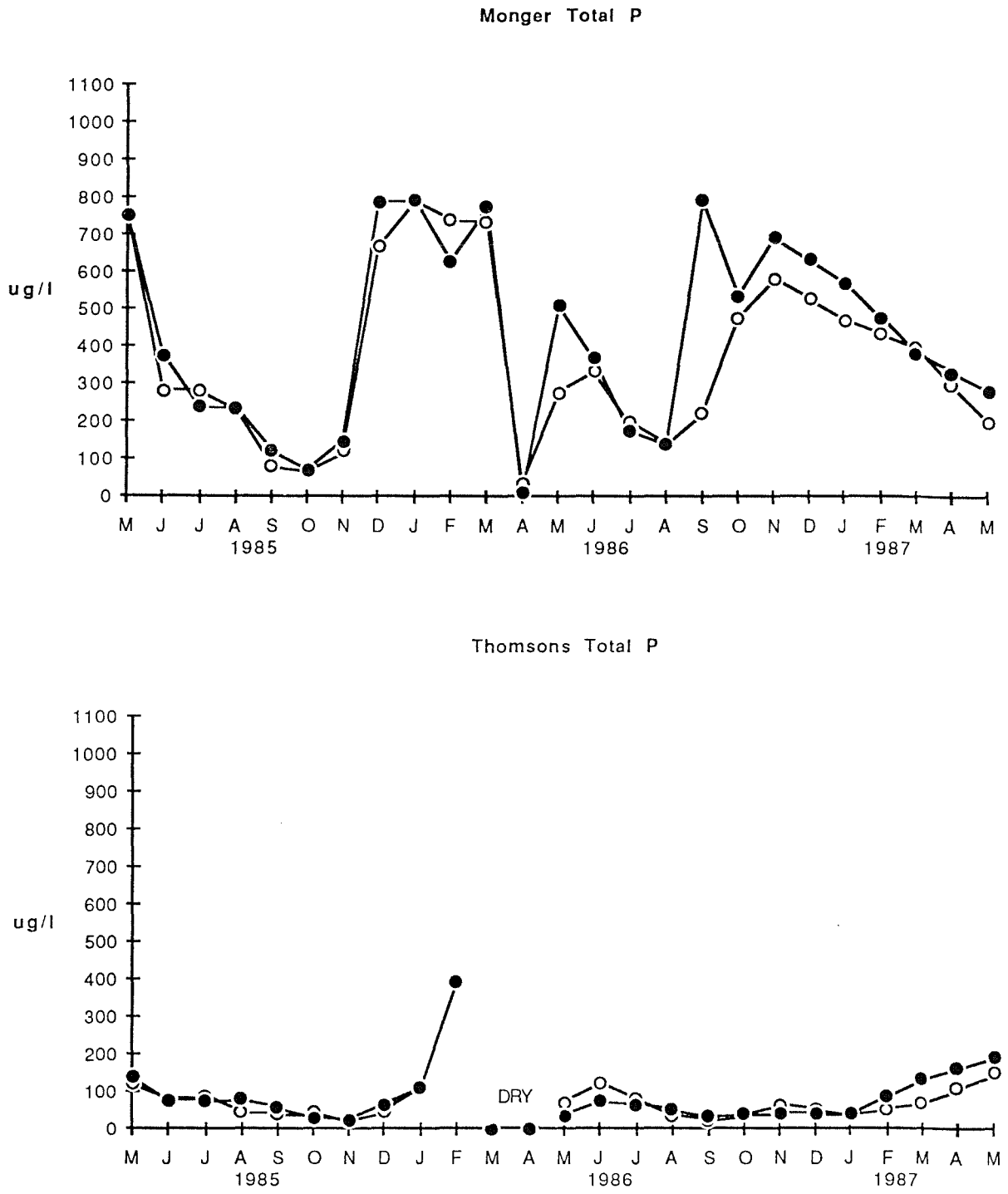


Figure 5. Monthly changes in total phosphorus concentrations over the period May 1985 to May 1987 at two sites in Lake Monger and Thomsons Lake.

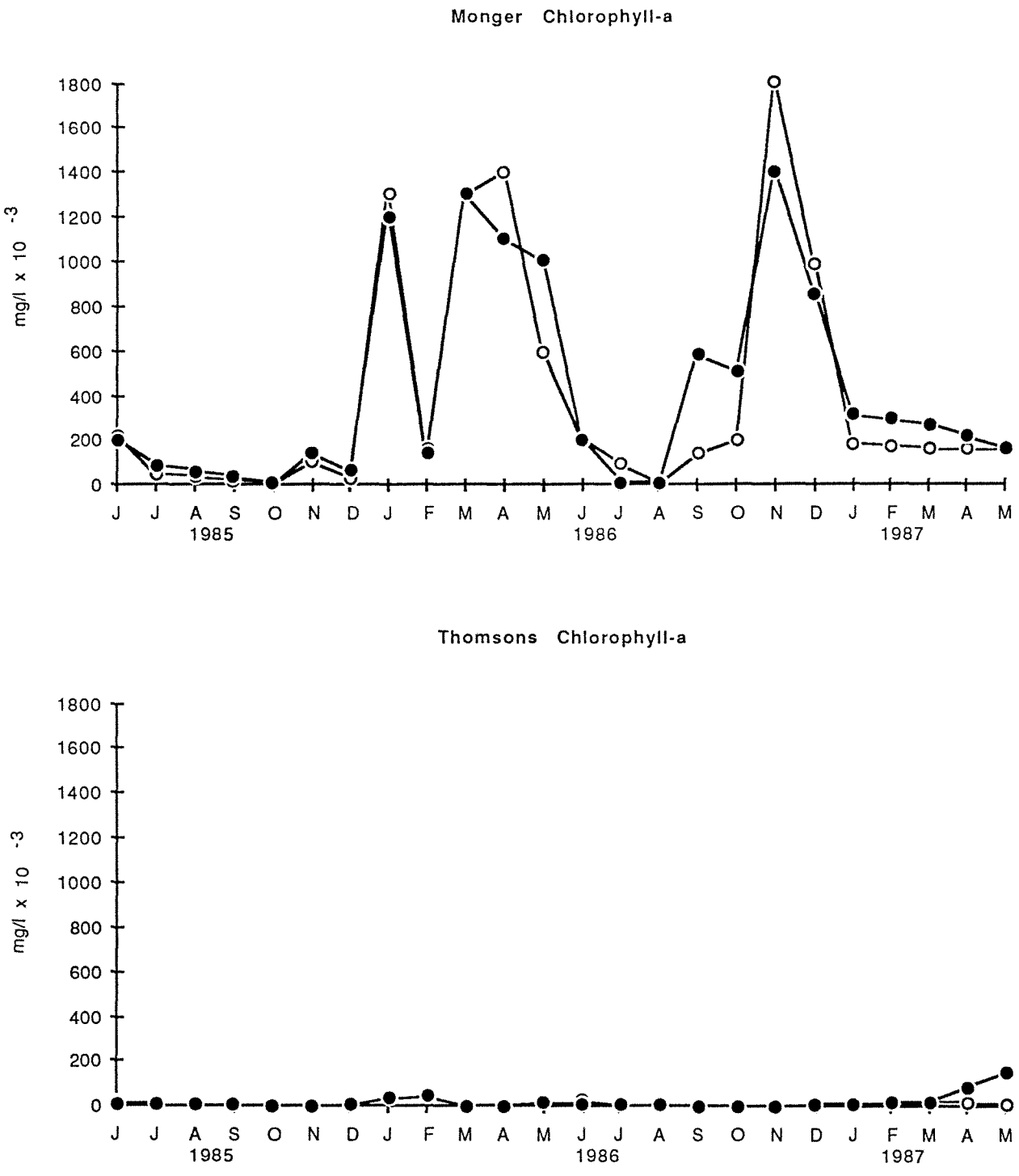


Figure 6. Monthly changes in chlorophyll a concentration over the period May 1985 to May 1987 at two sites in Lake Monger and Thomsons Lake.

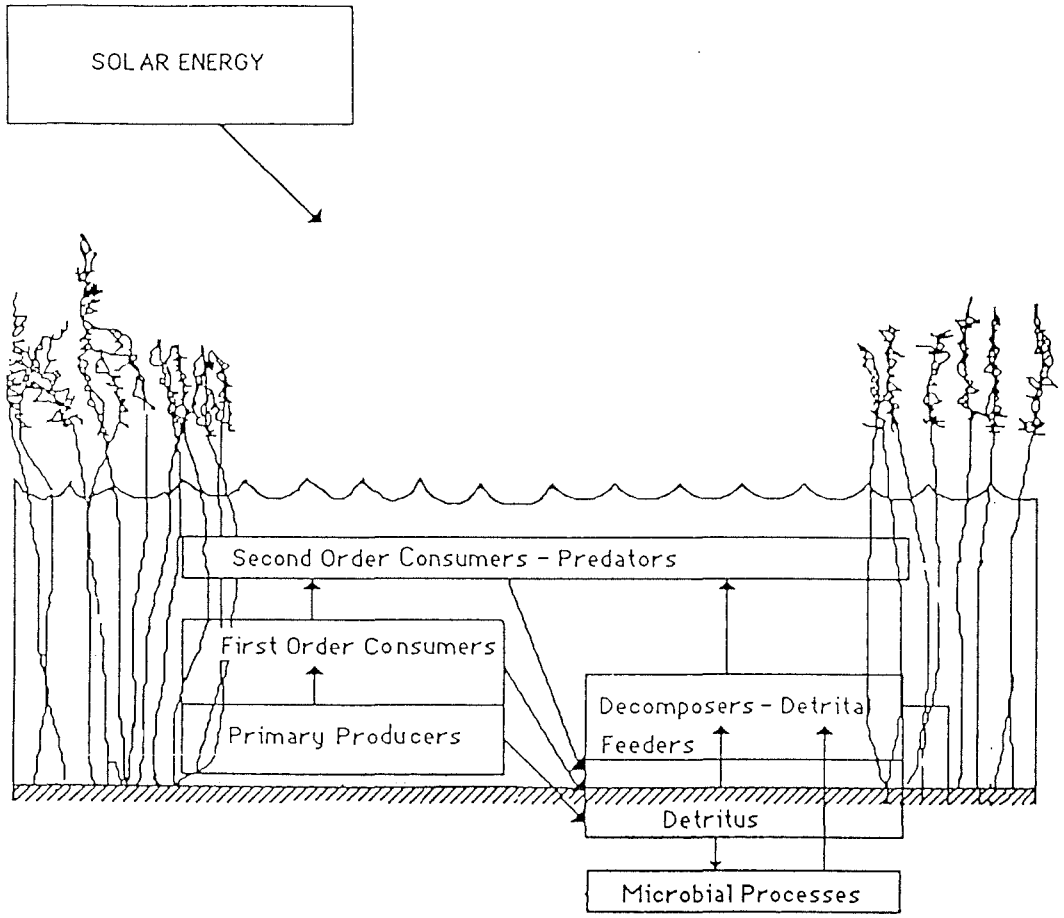


Figure 7. Diagrammatic representation of grazing and detrital food chains in wetlands on the Swan Coastal Plain.

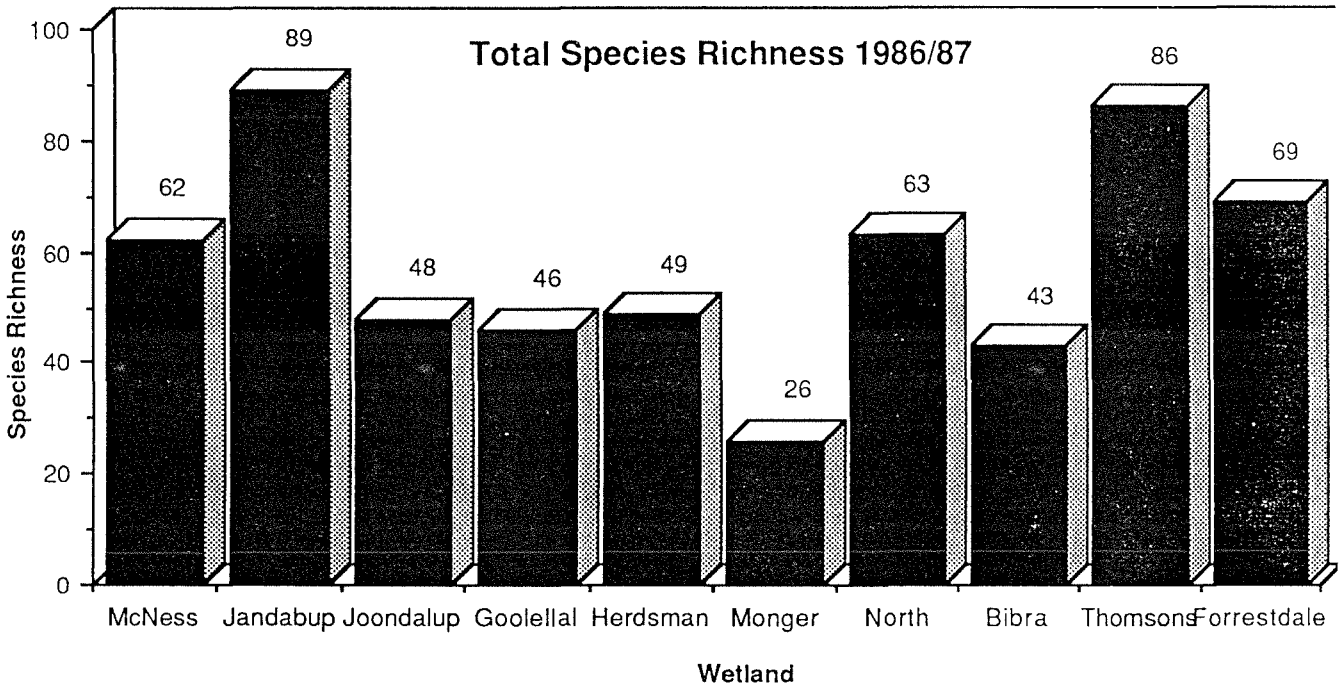


Figure 8. The total number of species of invertebrates recorded from ten wetlands on the Swan Coastal Plain over the 12 month period June 1986 to May 1987.

WETLANDS - A MANAGEMENT PERSPECTIVE

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ABSTRACT

The responsibility for the management of most wetlands of the Swan Coastal Plain rests with local government. The responsibility is not matched by adequate funding resources.

In the past, local government has used wetlands for purposes such as waste disposal and drainage disposal. Greater realisation of the conservation value of wetlands is now acknowledged. However urban development around wetland areas requires a balanced assessment of the competing demands placed on wetlands.

From a local government viewpoint, competing demands include stormwater disposal, recreational use, conservation and preservation, appearance, and safety and comfort needs of adjacent residents.

Urban development abutting wetlands results in demands on local government for action to overcome resident complaints on matters such as odours, midges, rubbish, safety and appearance.

The provision of an adequate buffer between urban development and wetlands substantially reduces this pressure. However, costs are involved in setting aside buffer areas. There is a need to identify these costs as a basis for making proper management decisions.

Wetlands in Special Rural Zone environments have given local government very few problems. The impact on the wetland from the development is minimal with few demands being placed on local government.

The type of management given to a wetland area is a function of the surrounding development. If conservation of a wetland area is deemed desirable from a regional perspective, funding for its protection must be a regional cost imposed on all the community, not just the local authority in which the wetland is situated.

Local government is well equipped to determine the correct management procedures to be adopted for any given wetland area. Local government must be involved in the planning processes that determine the uses of wetland areas within its boundaries.

BACKGROUND

Within the City of Cockburn there are extensive areas of wetlands. These wetlands vary considerably, in the nature of development surrounding the wetland and in the quality of the wetland. The wetlands have a significant impact on the City of Cockburn, impinging on major decision-making areas. Consequently, policy changes by Government or Government Departments on wetlands have the potential to have a considerable affect on the City of Cockburn.

RANGE OF DEVELOPMENT ENCOUNTERED

Manning Lake is an example of a wetland that has been extensively modified. Urban development has occurred close to its margins. Bibra Lake is remote from urban development but the western margin has been extensively developed for passive recreation following sanitary land filling of the southern and western lake foreshores. The eastern side of Bibra Lake has been left as natural bushland while efforts have been made to allow access by construction of dual-use paths and timber jetties. Lake Yangebup is remote from urban development with no improvements on the lake margins but is affected by industrial development.

At the other end of the scale are wetlands such as Lake Thompson which are currently in areas zoned rural and receive minimal impact from adjacent development.

COMMUNITY INFLUENCE ON WETLAND DEVELOPMENT

As urban development gets closer to wetland areas, the demand for development of the wetland increases. The general perception of the community is for manicured lawns and landscaped margins to lake edges. Such development is expensive. Manning Lake and Bibra Lake have been developed in this manner with assistance from Government employment schemes such as the RED scheme and more recently the CEP scheme. The funds necessary for the development may not have been so readily found without the financial support of these schemes. The ongoing maintenance needs of these areas are also high.

Wetlands remote from urban development receive less attention and are often allowed to remain in their natural condition. Examples are found in rural and special rural zoned areas.

REASONS FOR COMMUNITY COMPLAINTS

Pressures for development stem from a number of reasons. Most Local Government initiatives on wetland management are a response to complaints from local residents. Complaints fall into the following categories.

. Midges and mosquitoes spoil the outdoor living of the local community.

. Requests for clean-up of the area as a result of introduced weeds and rubbish.

. Requests to eliminate odours.

. The safety considerations are either requesting long grass be cut so snakes can be seen or the lake margins to be fenced to protect young children from drowning.

. Fear of flooding.

Local Government is in a position of having to take a community perspective of wetlands. If the community perceives a natural wetland as reducing the quality of lifestyle, then the local authority will be pressured to undertake works to improve the situation. The interface between developed surrounds and natural wetlands creates the greatest difficulty for Local Government.

Protection of wetlands in rural environments also can be a problem. Not all people respect wetlands. Dumping of rubbish and cats create major problems. Fires and access by four wheel drive vehicles can also play havoc on these areas.

PLANNING ISSUES

Integration of wetland areas into the urban environment needs careful consideration of a large number of issues. Wetlands of significance need an adequate buffer from urban development to ensure protection. The expansion of the Perth metropolitan area into existing rural areas will impact on wetland areas and criteria must be established so that wetland areas of significance are identified and protected. Local Government must be involved in the planning issues of wetlands. There are many competing demands on wetlands and Local Government representing community expectations has a significant role to play.

Creation of special rural zones in areas encompassing wetlands has proved to be very successful. This is an option to assist future management of wetlands. An example is Bartram Swamp. This swamp is identified as being of significance. It is protected as a reserve and surrounded by 2 hectare lots. No known complaints have come from this area since the creation of the special rural zoning.

FUNDING FOR MANAGEMENT OF WETLANDS

It is believed that Local Government has the capacity to efficiently and effectively fulfill the role as prime manager of wetlands. However, Local Government should not be expected to be the sole financier of this task. The costs can be very high and a local community requires direct financial assistance for wetland management. Wetlands need constant attention and with funding support, Local Government can provide the necessary attention.

MANAGEMENT OF WATER RESOURCES

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ABSTRACT

One of the Water Authority's primary corporate objectives is:

"To conserve, assess and efficiently manage the State's water resources for the continuing benefit of the community."

In the past, this has been largely achieved through the proclamation of water resource management areas. This provides the Water Authority with a statutory mechanism to ensure that activities in proclaimed areas do not degrade the quantity and quality of water and to enable the equitable allocation of the resource between public and private users. To a large extent, the proclamation of water resource management areas has also allowed for protection of the environment.

The objective of protecting areas of the environment became much more overt with the proclamation of the Wanneroo Groundwater Area in 1982. This was undertaken specifically to protect the valuable wetlands in the area. Acceptable wetland water levels are the major determinant in setting the availability of the groundwater for public and private use.

In March 1988, the Minister for Environment set a number of conditions on the next phase in the development and management of the Gnangara Mound groundwater resources. The conditions are founded on ensuring adequate protection and management of wetlands. The EPA has indicated that the Water Authority has the role of "total water resource manager". Where this management impinges on the environment, such as with wetlands, the Authority must also manage that environment to meet specific criteria.

Existing criteria for the protection of wetlands are fairly rudimentary. There is a real challenge to develop better water level and quality criteria which more effectively protect the valued attributes of wetlands. A number of research projects are being initiated to address this problem.

The recommendations of the Perth Urban Water Balance Study, if implemented by Government, will further facilitate the protection of wetlands, particularly those in urban areas.

WATER AUTHORITY OBJECTIVES

The Water Authority has two primary corporate objectives:

Provision of Services:

"To provide water, sewerage, irrigation and drainage services at minimum long-term cost and to an acceptable community standard".

Management of Water Resources:

"To conserve, assess and efficiently manage the State's water resources for the continuing benefit of the community."

It also has a number of supporting objectives including environmental considerations ie:

"To seek an appropriate balance between the costs of the Authority's activities, protection of the environment and the social expectations of the community."

There is considerable potential for interaction with wetlands in achieving these objectives.

In the provision of services, the Authority constructs dams and groundwater schemes which can have a direct effect on the quantity of water available to wetlands. Also, the provision of main drainage can have a direct effect on both the quantity and quality of water in wetlands.

If Perth is to continue developing, there is obviously a need for these services. However, such services must be designed and constructed in a manner which is sensitive to important wetlands.

As already indicated, the provision of services is only one aspect of the Authority's activities. It is in the overall management of the water resources of the State where the Authority must take full account of the importance of wetland areas.

LEGISLATIVE BACKGROUND

There are a number of Acts which form the legislative basis for the allocation and management of water in Western Australia.

The major ones are:

. Rights in Water and Irrigation Act 1914

. Metropolitan Water Supply Sewerage and Drainage Act 1911

. Water Authority Act 1984

. Environmental Protection Act 1986

The first three Acts are administered directly by the Water Authority. The Environmental Protection Act includes provisions for pollution control licensing which are delegated to the Water Authority for administration and the power to set environmental management criteria for wetlands which directly influences water allocation and use.

The basis for water management legislation, as identified in the Rights in Water and Irrigation Act, is that the "...right to the use and flow and to the control ..." of groundwater and surface water, is vested in the Crown.

The Water Authority Act provides that "the Authority is hereby charged, ..., with the duty of administering the right and interests of the Crown in and in relation to water in the State, of assessing, developing utilizing and conserving water resources, ..."

In the past, the objective of efficiently managing the water resources of the State has been largely achieved through the proclamation of water resource management areas. This provides the Water Authority with a statutory mechanism to ensure that activities in proclaimed areas do not degrade the quantity and quality of water and to enable the equitable allocation of the resources between public and private users and the environment.

The Water Authority has developed a three-stage approach to the proclamation of water resource management areas.

Stage 1: Being alert to any agricultural, mineral, municipal, town planning or industrial development which indicate a potential threat to the resource or to established water users (i.e. maintaining a watching brief).

Stage 2: Proclaiming areas where necessary to monitor increasing use of the resource more closely. Investigating and monitoring resource behaviour and determine long-term availability. Licencing existing use without restriction.

Stage 3: Introducing regulatory or restrictive controls in accordance with technical management strategies where monitoring indicates abstraction is approaching availability. Establishing advisory committees. Intensive monitoring and frequent reviews of performance and management strategies. Introducing metering as a last resort when other methods of measuring water use are inadequate for the level of management.

To a large extent, the proclamation of water resource management areas has also allowed for protection of the environment. For instance, the proclamation of water reserves and catchment areas has meant that in protecting both water quality and quantity upstream of water abstraction or diversion points, the areas of the environment which depend on that water, have also been conserved.

WANNEROO GROUNDWATER AREA

The objective of protection of valued areas of the environment became much more overt with proclamation of the Wanneroo Groundwater Area in 1982. This was undertaken specifically to protect the valuable wetlands in the area as well as to allow for a statutory mechanism to allocate the groundwater resource. In determining the quantity of water available to public and private users, the major determinant is acceptable wetland water levels.

In the Wanneroo Groundwater Area, it is the Water Authority, with assistance from such groups as the Western Australian Water Resources Council, which has historically carried out the bulk allocation of the resource. That is, the Water Authority determines how much water in total is available for abstraction and how much of that resource is to be allocated to public and private users. In allocating the resource to be used privately by individual licensed users, the Authority receives valuable assistance from Advisory Committees, such as the Wanneroo Groundwater Advisory Committee. The membership of such committees includes landowners who are nominated by the Local Authority, as well as representatives of relevant Government agencies.

IMPLICATIONS OF GNANGARA MOUND ENVIRONMENTAL APPROVAL

A significant recent event relating to the management of water resources occurred in March 1988, when the Minister for Environment set a number of conditions on the next phase in the development and management of the Gnangara Mound groundwater resources. These conditions are founded on ensuring adequate conservation and management of wetlands. Through the conditions, the Minister for Environment and the Environmental Protection Authority have indicated that the Water Authority has the role of "total water resource manager" and where the management impinges on the environment, such as with wetlands, the Water Authority must also manage that environment to meet specific criteria.

The existing criteria for the protection of wetlands are both rudimentary and restrictive. They are based on a combination of perceived community requirements for large open areas of water to provide an aesthetic landscape and a limited knowledge of the functions of aquatic ecosystems. But already, currently available research indicates that some of the criteria, particularly aimed at protecting aquatic ecosystems, may not be entirely soundly based. The research by Davis and Rolls (1987) shows that for some lakes, there are significant benefits in them drying out on occasions. Historical records and anecdotal evidence indicate that this is likely to have occurred during dry periods earlier this century. In considering how this should be incorporated into wetland criteria, we must not lose sight of the need to ensure summer drought refuges for waterfowl in the deeper lakes.

There is therefore a real challenge to develop better water level and quality criteria which more effectively protect the valued attributes of wetlands. For wetlands where human attributes are important, we need to have a better understanding of community expectations for aesthetic landscapes and recreational needs. Where natural attributes are more important, we need to know how the vegetation and fauna are affected by changing water levels and water quality. A significant number of research projects are being initiated this year aimed at providing us with a better understanding of both the valued attributes of wetlands and of wetland processes.

INTEGRATED CATCHMENT MANAGEMENT

The setting of conditions on the development and management of the Gnangara Mound Groundwater Resources was also one of the main catalysts behind the establishment of the Integrated Catchment Management Policy Group. This high-level Government committee was set up in recognition that the development and management of water and land resources needed to be integrated to be effective. It is no use having strict conditions applying to the development of water resources if there is no control over the way the land above the water resources is used. Changes in land use have the potential to have a significant effect on the quality and quantity of water resources and therefore on the wetlands which depend on that water for their very existence. The catchment or water basin is seen as the logical unit for integrating the management of specific areas.

The Integrated Catchment Management Policy Group is to be supported by Advisory Groups, set up to provide specific advice on important water basins. The Gnangara Mound Technical Advisory Group has already been established and includes members of all relevant Government agencies and representatives of two local authorities.

PERTH URBAN WATER BALANCE

Another important event in the management of water resources was the release last year of the report and recommendations of the Perth Urban Water Balance Study (1987). The main recommendation of this report related to the proclamation of the metropolitan region to enable the licensing of non-domestic bores. Sixty to seventy percent of the groundwater abstracted privately in the Perth area is used by non-domestic users (this includes Local Authorities) and management of this component of use can be undertaken with relatively little effort. If the Government decides to implement these recommendations, it will facilitate greater protection of wetlands in urban areas.

WHAT CAN LOCAL GOVERNMENT DO?

Local Government can play a very important part in the protection and management of wetlands. A basic requirement in protecting wetlands is to first protect and manage the quantity and quality of the water resource sustaining the wetlands.

Quantity

- Aim at efficient use of the water resource:
  - efficient watering of recreation areas (e.g City of Stirling);
  - use of low water-use landscaping wherever possible.

- Maximise groundwater recharge wherever possible:
  - local recharge drainage waters;
  - encourage flush edged kerbing on roads or porous pavements;
  - use grassed or vegetated swale drains;
  - minimise "export" of drainage waters;
  - minimise changes to the water balance.

  - Assist in educating the public on the importance of water conservation

Quality

- Ensure that land uses up gradient (i.e. in the water catchment) of wet are compatible:
  - avoid over fertilisation of recreation areas;
  - avoid fertiliser intensive rural pursuits;
  - avoid intensive animal industries;
  - avoid industries producing toxic wastes;
  - avoid sending drainage waters into significant wetland areas.

General

- Ensure that Council decisions relating to planning policies, rezoning etc, consider water resource aspects.

- The long-term protection and security of the water resource and the wetlands should be of greater importance than short term, politically expedient, decisions.

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CATCHMENT MANAGEMENT AND IN-LAKE SOLUTIONS

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ABSTRACT

Waterbodies, be they wetlands, lakes, rivers or estuaries, can be changed by direct modification or by alterations in drainage from somewhere in the catchment. Changes to drainage may increase or decrease the amount of water flowing in, alter discharge patterns or decrease water quality.

Nearly all problems arising from these changes require a package of management options involving both the waterbody and its catchment. There is rarely a single or easy solution.

This paper outlines a systematic approach to developing a strategy for managing water quality problems. The approach is based on an understanding of the problem, the waterbody and its catchment. It is, however, not reliant upon a 'complete' knowledge of the environment, as this is a luxury nobody can afford.

Having described the waterbody and its problem, a 'suitable' suite of management options is selected, evaluated and modified to suit the particular case.

The types of management actions contemplated could include:

- manage drainage to control volume discharged;
- treat polluted drainage water;
- create artificial wetland filters;
- treat point sources of pollution (e.g. factories);
- manage non-point sources of pollution (e.g. fertilizer use);
- change land-use;
- harvest weeds;
- remove sediments;
- inactivate sediment nutrients.

The process of evaluation is guided by the level of improvement sought to achieve desired beneficial uses, cost, social impacts and feasibility in relation to existing land and water uses.

Once a decision is made on appropriate management actions, an adaptive management strategy is implemented. This involves monitoring, evaluation and adjustment of management actions as necessary to effect the desired improvements.

A rational approach to the problems of catchment and water quality management has five main elements: problem definition, determination of catchment properties, determination of waterbody properties, management, public involvement and education.

The resolution of a water quality management problem relies upon an understanding of the inputs of polluting substances, and the ability of the receiving waterbody to handle pollutants without damage - its "assimilative capacity".

Management strategies can be developed by assessing catchment pollution sources, the behaviour of the waterbody and its response to inflowing pollutants.

Sufficient information can be collected to achieve these objectives using basic, relatively inexpensive measuring techniques for a minimum of 12 months. It may be necessary to do further follow-up work of a period of years to fine tune management, or to develop more complex management strategies to achieve desired water quality goals. However, it should be emphasised that this need not be necessarily so.

This paper presents the basic steps necessary to understand a water quality problem, and to develop a management strategy to achieve desired water quality objectives. The section numbers in this paper correspond with the steps summarised in Figure 1.

1. PROBLEM DEFINITION

1.1 WHAT ARE THE PROBLEMS?

A water quality problem can come to light in a number of ways. People may complain of excessive weed fouling of beaches, wildlife deaths, unpleasant water conditions (odours, colour, feel) or Local Government Health officers may detect a health problem. It is important to note that there may be several problems developing at once, even though only one or two symptoms may be the subject of complaint.

Most water quality problems result from the inflow of pollutants from activities in the catchment of the waterbody. Therefore, the approach to a problem in the waterbody must include an analysis of its catchment. Pollutants may enter a waterbody via drainage networks, groundwater inflow, and in some cases the atmosphere.

1.2 CALCULATION OF THEORETICAL CATCHMENT PROPERTIES

An analysis of the waterbody's catchment and its properties is useful, since it assists in determining an approach to resolving the problems.

Firstly, identify the drainage basin of the waterbody and the range of land use activities within this catchment. This information can often be gained from local government and other local records fairly quickly. Information on land use facilitates the identification of likely pollution sources, eg. nutrients (nitrogen and phosphorus) from broad-acre agriculture, rural point sources such as piggeries, stables and animal holding yards, horticulture (ie market gardens), sewage works, urban areas and industry, toxic substances such as lead from road runoff, and chromium from tanneries and metal plating works.

The theoretical runoff from the catchment and leaching characteristics of soils can be calculated from existing information, for example rainfall records, general soils information, runoff characteristics from similar catchments and nutrient and pollutant leaching studies done elsewhere.

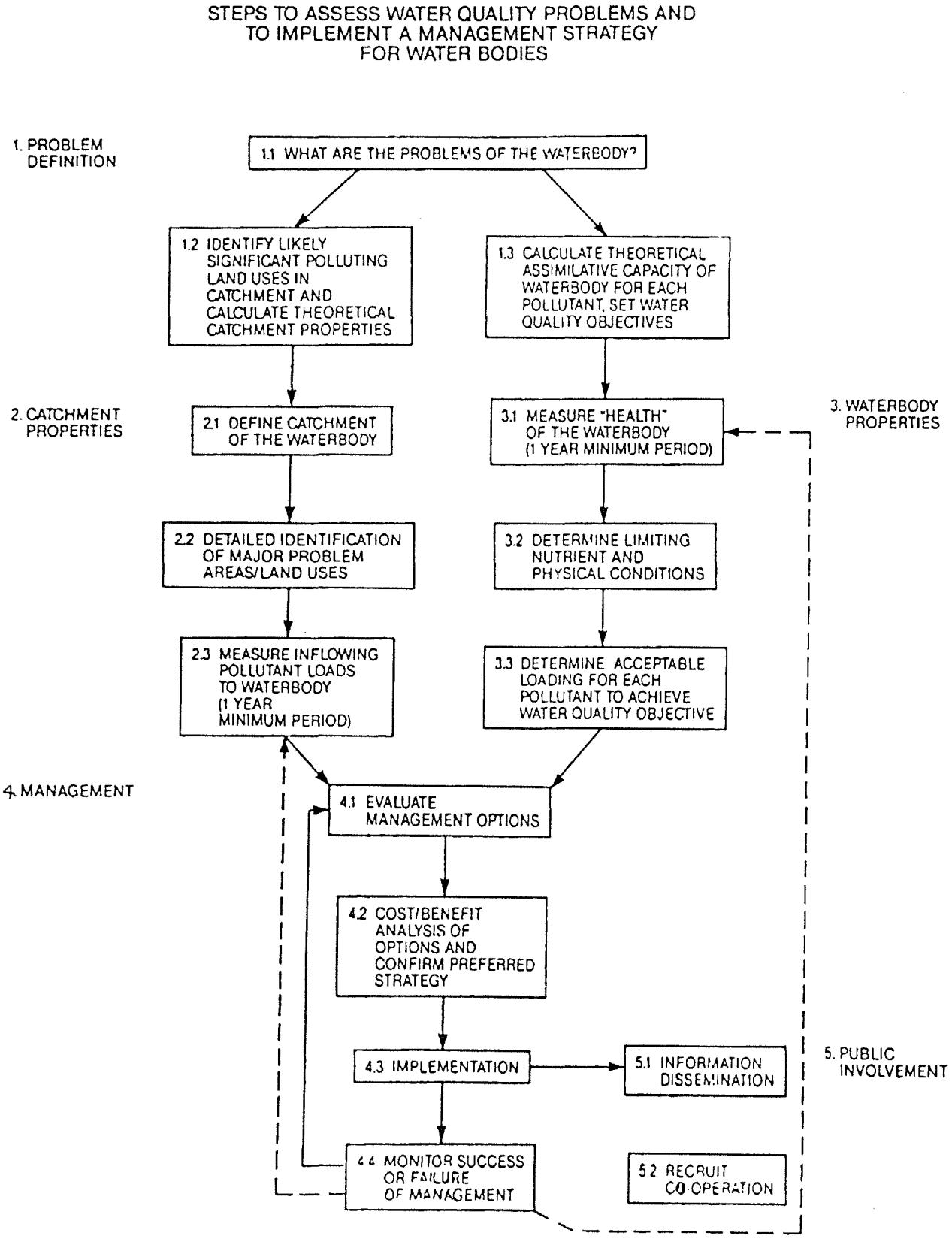

Figure 1. Steps necessary to understand a water quality problem and develop a management strategy.

1.3 CALCULATION OF THE THEORETICAL ASSIMILATIVE CAPACITY OF A WATERBODY

Waterbodies are able to tolerate differing levels of pollution before their biological and chemical systems begin to show changes, many of which are undesirable.

The capacity of a waterbody to tolerate pollutant inputs without major change is known and its "assimilative capacity". In general, larger waterbodies can assimilate more pollution than can smaller ones, and better flushed systems are more tolerant of pollution than are poorly flushed ones.

Various mathematical techniques exist to estimate the assimilative capacities of waterbodies, particularly for plant nutrients, such as nitrogen and phosphorus. The degree of algal growth in a waterway is related to the rate of nutrient supply (eg. grams of phosphorus per square metre of waterbody surface area per year ($g/m^2/a$), and the gross flushing rate, or water loading of the waterbody (eg. total water inflow from all sources (m^3/a) divided by the surface area (m^2) of the waterbody which gives (m/a).

This relationship is plotted for several Western Australian estuaries in Figure 2. Annual phosphorus loading is plotted on the vertical axis, and water loading (m/a) is plotted on the horizontal axis. This graph shows that better flushed estuaries tolerate higher annual loadings of phosphorus. This form of relationship is also true for nitrogen and may be applicable for other pollutants, such as heavy metals.

The information necessary to calculate the theoretical assimilative capacity of a waterbody includes:

- Surface area of the waterbody (m^2)
- Mean depth (m)
- Average volume (m^3)
- Total water inflows from all sources (m^3/a), including tidal exchange, drain inflows, groundwater seepage and direct rainfall onto the water surface over an annual cycle.

This information may be available from government agencies, or data from similar systems studies elsewhere may apply. Gross flushing rates for groundwater - dominated wetlands on the Swan Coastal Plain are probably about 0.5 - 2.0 m/a.

Once this information is available, the calculation may be simply done with a hand calculator. A sample calculation for estimating the phosphorus assimilative capacity of North Lake is reproduced below:

North Lake Sample Calculation

Based on the graph shown in Figure 2 and a water loading or gross flushing rate of between 0.5 - 2 m/a, the maximum permissible phosphorus loading is 0.2 $g/m^2/a$ to prevent the wetland becoming eutrophic.

Calculation of Maximum Permissible P loading

Lake surface Area = 50×10^4 m^2

Maximum permissible phosphorus loading = 0.2 g m^2/a

> Maximum permissable P input per year = 50×10^4 m^2 x 0.2 $g/m^2/a$
> = 100×10^3 g/a = 100 kg/a

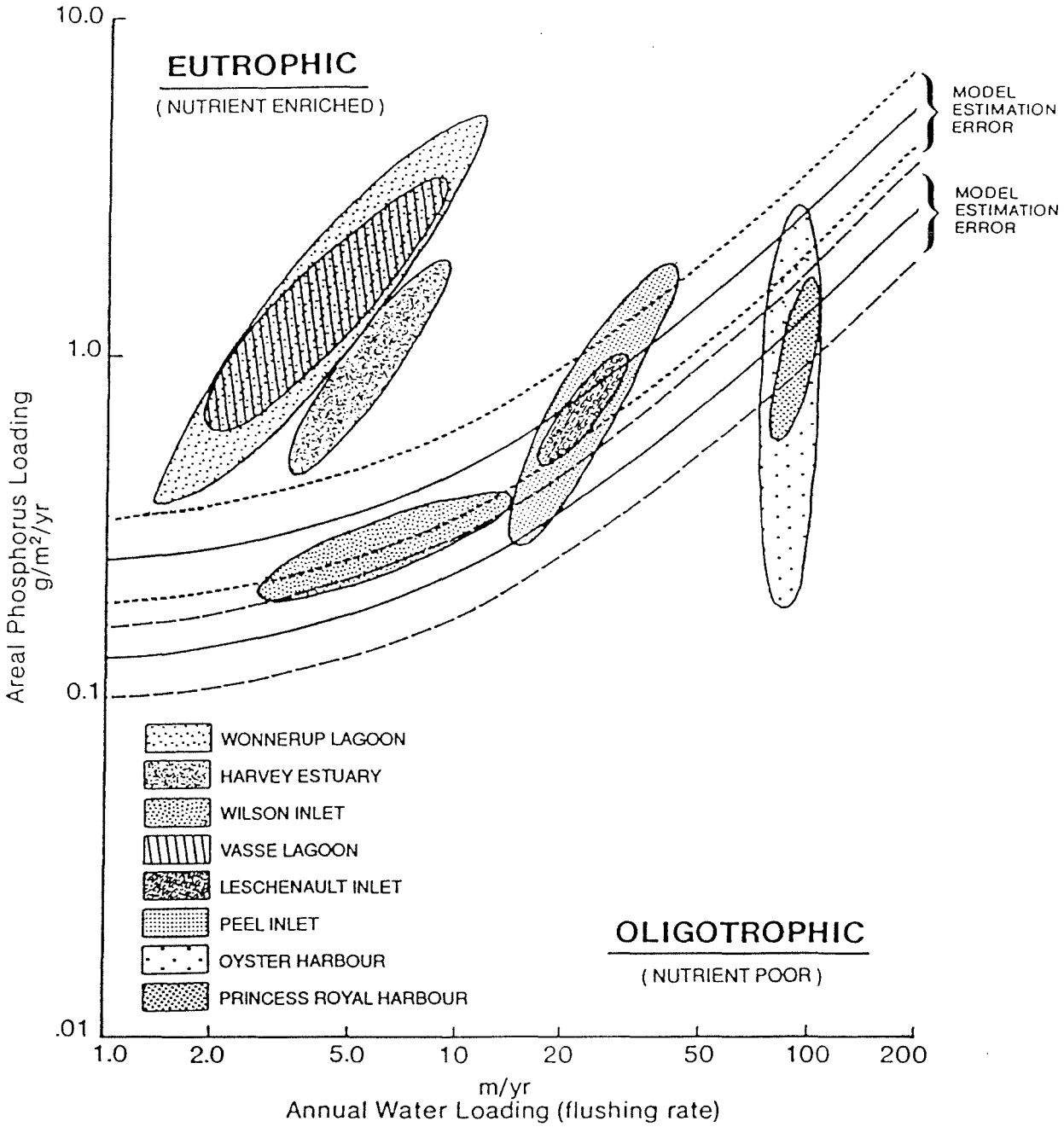

Figure 2 : Relationship between areal phosphorus loading and annual water loading, showing the trophic status of some South-West estuaries (McAlpine et al 1989). Adapted from work by Vollenwieder and Reckhow, referenced in McAlpine et al, 1989.

Calculation of Annual Permissible Water Inflow Volume Based on the Flow-Weighted Mean Phosphorus Concentration

The procedure for determining the flow weighted mean concentration is described in Section 2.3.

Assume Flow Weighted Mean P Concentration = 0.6 mg/l P
$= 0.6 \times 10^{-3} \times 10^{3}$ g/m^3 P
$= 0.6$ g/m^3 P

Assume one-third of maximum permissible phosphorus loading to the lake is contributed from groundwater flows. Therefore:

Maximum Permissible Surface Inflowing P = 66 kg

Therefore Maximum Volume of surface inflow (m^3) @ 0.6 mg/l =

$$= \frac{66 \times 10^{3} \text{ g}}{0.6 \text{ g/m}^3}$$

$= 111$ m^3

These results have not been assessed in relation to the ability of North Lake to absorb these volumes of water - a rise in water level will occur if inflow volumes are larger than the lakes capacity to hold them, and local flooding may occur.

The next step is to determine the beneficial uses for the waterbody (eg. swimming, taking of fish for food, boating) then set water quality criteria objectives to protect these beneficial uses. The need for this will become apparent in Section 3.3.

2.0 DETERMINATION OF CATCHMENT PROPERTIES

The section numbers below refer to the numbered boxes in Figure 1.

2.1 CATCHMENT DEFINITION

Determine the catchment boundary for each drain from a suitable tipographic map, then survey and map land use. Include a soil survey, groundwater flow patterns and sub-catchment characteristics.

2.2 DETAILED IDENTIFICATION OF LAND USES

Determine which activities and land forms contribute to the high nutrient loads, or are sources of other pollutants. Areas to note include heavily fertilized farms or grassed areas, intensive rural activities, and some industrial pursuits.

2.3 MEASURE IN FLOW OF POLLUTANTS

- Identify the most likely major inputs based on existing data, and build continuous recorder stream flow stations. Measure the total annual water (discharge) for at least one year.

- Sample the stream flows for a range of dissolved and particulate substances (including nutrients and metals) at least weekly, and more frequently during storm flows for at least one year. Stage height samplers are excellent method for collecting samples of storm flows.

. Calculate inflowing loads of nutrients, metals and other pollutants of interest.

A sample calculation of instantaneous and annual phosphorus loads is given below:

(i) Instantaneous P load

load in grams of phosphorus per second (g/s)

= Flow (m^3/s) x concentration (g P/m^3)
= m^3/s x g/m_3 = g P/s

The instantaneous loads are summed for the whole period of measurement - for example one year. This summation gives an annual phosphorus load in grams/year - or in any other appropriate unit of mass - kg or tonnes.

The flow-weighted mean phosphorus concentration, or the true "average" concentration in the flow is calculated as follows:

$$\text{Flow weighted mean P concentration} = \frac{\text{Annual P load}}{\text{Total annual flow}} \quad \frac{g\ P/a}{m^3/a} = g\ P/m^3$$

3.0 DETERMINATION OF WATERBODY PROPERTIES

3.1 MEASURE THE "HEALTH" OF THE WATERBODY

The response of a waterbody to inflowing contaminants may be assessed by measuring:

- The size of the pollutant's sediment store and distribution.

- The degree of uptake by plants of nutrients and metals.

- What types of plants occur in the waterbody, for example phytoplankton diatoms, green or blue-green algae, or other aquatic vegetation such as seagrasses, large algae or emergent waterweeds or rushes.

- Whether consumption of animals from the waterbody presents a health risk to humans.

Specifically, the following should be monitored.

. Water quality (nutrients, other pollutants, bacteria, algae) at a range of sites that are representative of the waterbody weekly or at least fortnightly for one year.

. Sediments for nutrients (available and mineralised) organic matter, metals (lead) and composition (sand, silt, clay) two-four times in one year.

. Conduct at least two vegetation surveys to determine distribution, species composition and standing crop (abundance). Measure tissue levels of nitrogen, phosphorus and heavy metals.

. Collect samples of filter feeding animals (eg. mussels) and measure their tissues to assess the concentration of metals and other pollutants.

3.2 DETERMINATION OF THE LIMITING NUTRIENT AND PHYSICAL CONDITIONS

Plants (algae and seagrasses) require nitrogen and phosphorus for growth. It is generally accepted that these nutrients are used in a ratio (by atoms) of between 10:1 to 15:1 nitrogen to phosphorus. That is, ten times more nitrogen than phosphorus is needed for adequate plant growth. A ratio greater than 10-15:1 means that nitrogen is in excess and phosphorus is limiting plant growth, and a lower N:P ratio means that phosphorus is in excess and nitrogen is probably limiting plant growth. Nitrogen to phosphorus ratios of 4:1 or less favour the growth of plants that can fix nitrogen from the atmosphere such as blue-green algae. Blue-green algae are toxic to many animals, and are a severe problem in many lakes and estuaries on the Swan Coastal Plain.

The N:P ratio is calculated from data collected in steps 2.3 and 3.1, and can be measured for the nutrient inflows, the waterbody itself, or for the tissue of plants living in the system.

$$\frac{N}{P} = \frac{gN/l}{gP/l} \times \frac{31}{14}$$

Limiting physical conditions may include lack of light for aquatic plant growth if the waterbody is turbid or lightly coloured, and barriers to flushing such as a sand bar or tidal gates.

3.3 DETERMINATION OF "ACCEPTABLE" LOADING

Having calculated the assimilative capacity of the waterbody, nutrient loadings from the catchment, the biological response of the waterbody to inflowing nutrient or other pollutant loads, and estimated the likelihood of health risk, the water quality objectives to achieve "acceptable" loadings of pollutants to the waterbody can be determined.

An "acceptable" loading is one that can be accepted by the waterbody (and therefore does not exceed its assimilative capacity) without causing an unacceptable biological response (eg. beach fouling of weed) or a health risk (contaminated aquatic life taken for food or a disease risk to swimmers). That is, an "acceptable" the loading does not cause any of the established water quality objectives to be exceeded. Bulletin 103 (Department of Conservation and Environment, 1981) provides a compelation of suggested water quality criteria for Western Australian marine and estuarine waters. These criteria are mostly relevant for inland waters as well.

4.0 MANAGEMENT

The primary objective of a preferred management strategy is to maintain the quality of the waterbody for established beneficial uses by not allowing drainage discharged to it to cause water quality indicators to exceed the acceptable levels.

4.1 EVALUATION MANAGEMENT OPTIONS

A variety of management actions are possible, and may include one or a combination of the following:

. manage drainage to control the volume of water and pollutants discharged;

. treat polluted drainage water to remove dissolved or suspended pollutants;

. create artificial wetland filters upstream of the waterbody to reduce pollutant loads downstream;

. treat and reduce point sources of pollution (eg. factories, piggeries);

. reduce non-point sources of pollution (e.g. fertilizer use);

. change land-uses to substitute polluting activities with less polluting ones;

. harvest weeds to reduce beach fouling or other problems;

. remove sediments to reduce the levels of nutrients or other pollutants in the waterbody;

. inactivate sediment nutrients with appropriate chemicals to reduce their recycling within the waterbody;

This list is not exhaustive, and each option needs thorough evaluation to determine its environmental, social, technical and economic acceptability. Humphries and Croft (1984a, 1984b and 1984c) outline this process in more detail for the eutrophic Peel-Harvey Estuary.

Evaluation of options is usually at least a two-stage process, with many options being discarded after preliminary appraisals, with those surviving the first stage being subjected to more detailed scrutiny.

It is vital to calculate the likely contribution, and the degree of permanence, of each option being evaluated to solve water quality problems. It is futile to implement expensive management options which will not work, or which will not control problems effectively. Thorough, critical review of proposed management strategies is essential to reduce the likelihood of failure, and to ensure that elementary errors or omissions have not occurred.

4.2 COST/BENEFIT ANALYSIS

The analysis of the costs and benefits of management of a waterbody are really part of the evaluation of management options. However, it is important to value:

. the wetland in social, environmental and economic terms;

. the value of polluting catchment activities, and the ability of the polluter(s) to pay for management.

In the case of the Peel-Harvey Estuary, the proposed management strategy is estimated to cost about $50 million. This may seem expensive, but the costs of restoration can be viewed in perspective if the potential recreational value of the estuary is determined (hundreds of millions of dollars), and the annual value of agricultural production ($60 - $100 million) is accounted for. If the community wants the estuary restored and agriculture to continue as a major land use, then the $50 million cost of management begins to look reasonable.

4.3 IMPLEMENTATION

The success of implementation is critically determined by the willingness of everyone involved to co-operate. Most catchment management problems arise from the combined activities of dozens or hundreds of land users, rather than from one or two large sources of pollution.

Various methods of encouraging informed cooperation are used, and involve all levels of government and the community. Public education is essential to ensure awareness of waterbody management problems, and to ensure support for the steps necessary to correct them.

4.4 MONITORING

Monitoring the success of the strategy and the response of the waterbody to management measures, for example the reduction of nutrient levels in drainage and the consequent reduction of excessive plant growth or algal blooms, is an essential part of the implementation of a management plan.

Should monitoring show that the agreed management objectives are not being achieved, then the strategy should be re-evaluated and modified where necessary.

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REGIONAL PLANNING

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ABSTRACT

The value of wetlands to the urban and rural environment is accepted by the community and local government, particularly along the Swan Coastal Plain but also elsewhere in Western Australia.

The means available to protect these wetlands and ensure their use as areas of natural habitat, untouched ecosystems, and urban leisure areas lie primarily with the State Planning Commission in the first instance. Regional Plans can identify areas for protection and reservation and can co-ordinate the locations of various activities and transportation links to avoid those protected areas.

Regional planning is not new in Western Australia. The Metropolitan Region Scheme, as a Statutory Plan, dates back to 1963. Other regional plans, although not statutory, relate to places like Bunbury, Shark Bay and the Leeuwin-Naturaliste area.

Regional plans form the basic framework within which local government can undertake detailed planning, and other instrumentalities can co-ordinate activities such as catchment management, forestry and agricultural uses.

OVERVIEW

Almost everyone connectedwith the use,management, protectionor investigation of wetlands has a conception of what regional planning is. Even though each individual may have a slightly different version, probably they would all be close to a reasonable definition. Broadly speaking, regional planning is a means of identifying and co-ordinating or controlling future activities, usually by means of some form of land use control. In Western Australia, we have two types of regional plan to cite as examples, namely;

The Statutory Regional Plan implemented by an Act of Parliament. (The Perth Metropolitan Region Scheme is the prime example, and its attributes will be outlined).

The Regional Planning Policy implemented generally by co-operation from local government, but also possible as a statutory policy under Section 5AA of the Town Planning & Development Act.

These two alternatives are examined in the context of the topic "Wetlands in Crisis - What Can Local Government Do?"

A STATUTORY REGIONAL PLAN - THE METROPOLITAN REGION TOWN PLANNING SCHEME

THE METROPOLITAN REGION TOWN PLANNING SCHEME ACT

The Metropolitan Region Scheme has its own Act of Parliament - The Metropolitan Region Town Planning Scheme Act, which was assented to on December 14, 1959. The long title of this act states: "An Act to provide for and relating to the Planning and Development of land within the Metropolitan Region, and to regulate the assessment of a Metropolitan Improvement Tax and for incidental and other purposes."

From this it can be seen that the act has at least four aims:

. The planning of land within the Metropolitan Region.

. The development of land within the Metropolitan Region.

. The regulation and assessment of a Metropolitan Improvement Tax.

. Incidental and other purposes.

Within this discussion we are interested in all four aims, but particularly the first three.

RESERVES

The other statutory parts are the Metropolitan Region Scheme text, and the scheme maps which detail the various parts of the scheme, such as the reserves, the zones, development finance and administration.

It is the reserves that interest us most in the context of "Wetlands in Crisis" and the ability for the State, through the Metropolitan Region Scheme to reserve specific parcels of land for Parks and Recreation purposes.

Clause 34 of the Metropolitan Region Town Planning Scheme Act emphasises the importance of this by stating that the Minister for Planning cannot approve a Local Government Town Planning Scheme unless it is consistent with the Metropolitan Region Scheme.

Further, where the Metropolitan Region Scheme is amended by the addition of or extension of land zoned for a public purpose, such as Parks and Recreation, then the local scheme is automatically amended accordingly, without the need to take action under the Town Planning and Development Act.

THE IMPLICATIONS FOR WETLANDS

When Gordon Stephenson and Alistair Hepburn prepared the first regional plan in W.A., the "Plan for the Metropolitan Region Perth and Fremantle" (Fig 1) on which the Metropolitan Region Scheme was based) they emphasised the importance of "Regional Open Space".

Their scheme report states: (P 95)

"Regional Open Space"

"The provision of open space in this category is not subject to the imposition of theoretical standards. The quantity and distribution derives largely from an examination of areas considered suitable for particular uses, independently of any calculation of local or District Open Space".

The report continues by outlining the importance of: ocean beaches, rivers and river foreshores, areas of landscape value, picnic areas, camping grounds, nature reservations and others.

Although this report does not specifically mention wetlands, the plans prepared recommended the reservation of all river foreshores, and of the prime wetlands within the developed area at the time. The significance was that it set the scene for the Metropolitan Region Scheme, and has resulted in a statutory scheme that is reserving those wetlands under pressure from a growing urban population.

Thus we now have a Region Scheme, (Fig 2) that is structured so that wetlands can be (and are) reserved or protected rather than zoned for development. The scheme text states at Clause 13 "... no person shall commence or carry out any development on reserved land, other than the erection of a boundary fence, without first applying for and obtaining the written approval of the Commission to do so."

This means quite conclusively that the State has the power to prevent development on land reserved in the scheme. There is one further extremely important factor coming from the 1959 Act and that is the Metropolitan Improvement Tax, levied on all metropolitan properties other than the single residential property where the individual resides. It is because of this that where development is refused, the owner can claim compensation by having his property purchased by the Commission. Through this scheme, the State Planning Commission reserves some 34,000 hectares of land for Parks and Recreation purposes.

Of this some 16,000 hectares is already crown land, and 13,900 hectares has been purchased by the Commission leaving about 4,000 hectares in private and local government ownership. Of course the scheme is not static, and further scheme amendments are continuing. Recent amendments cover Ashfield Flats, Bennett Brook, Wungong Gorge etc.

THE ROLE OF LOCAL GOVERNMENT

It is at this stage that local government becomes important, and needs to operate in close partnership with the State Planning Commission in determining priorities, assisting with management, having a major input into reserve boundaries and land use plans.

Local Government involvement forms part of the statutory provisions in that the District Planning Committees are created by the Act, and are actively used to ensure local government involvement. There were five district planning committees, initially the North West, the South West, the Eastern, the South Eastern and the City of Perth.

SUMMARY

To summarise, the Statutory Regional Plan provides for the protection of wetlands by:

- the creation of reserves;
- the provision of improvement funds for the purchase and management of these reserves and for compensation;
- the direct involvement of local government.

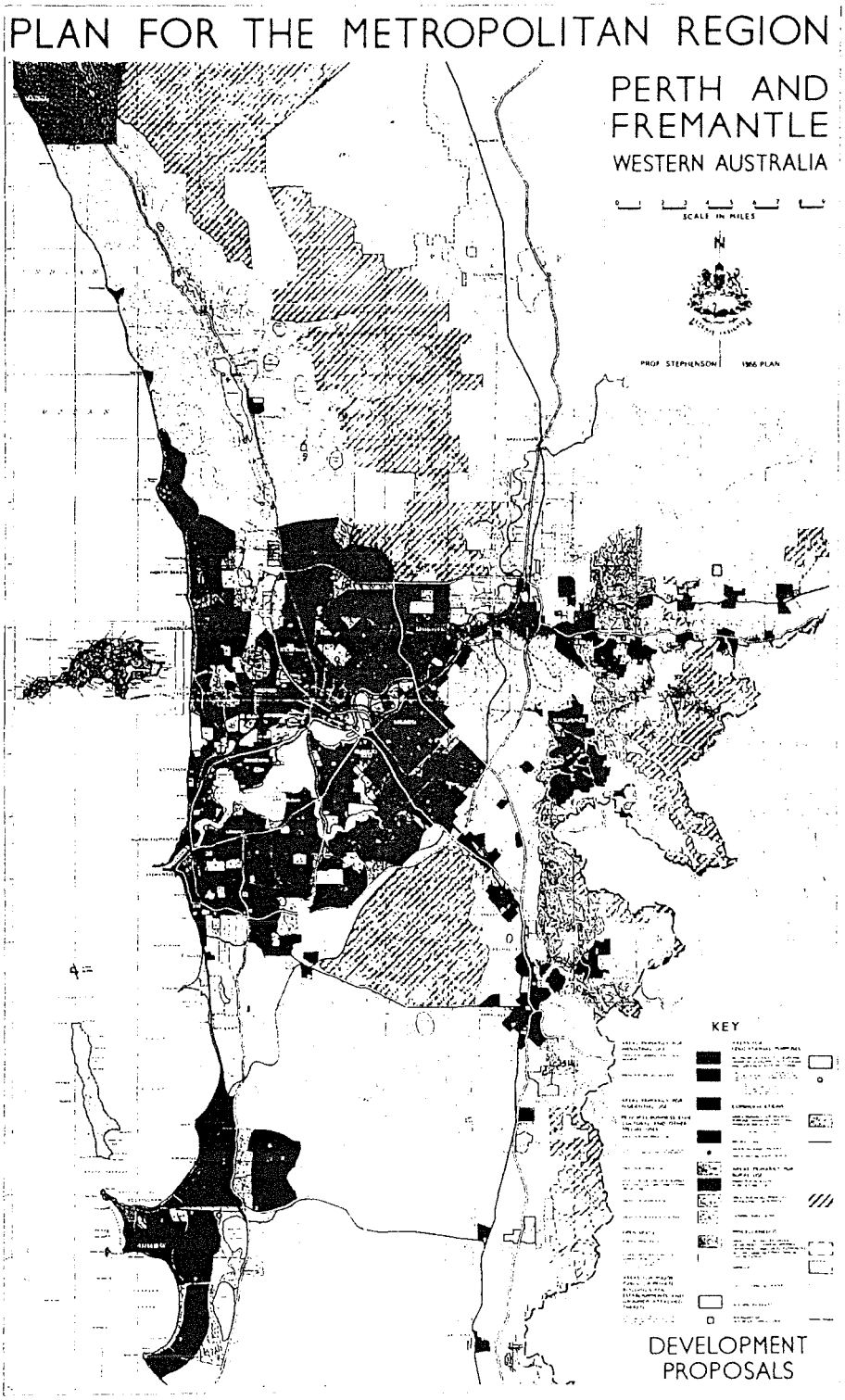

Figure 1. Plan for the Metropolitan Region : Perth and Fremantle.

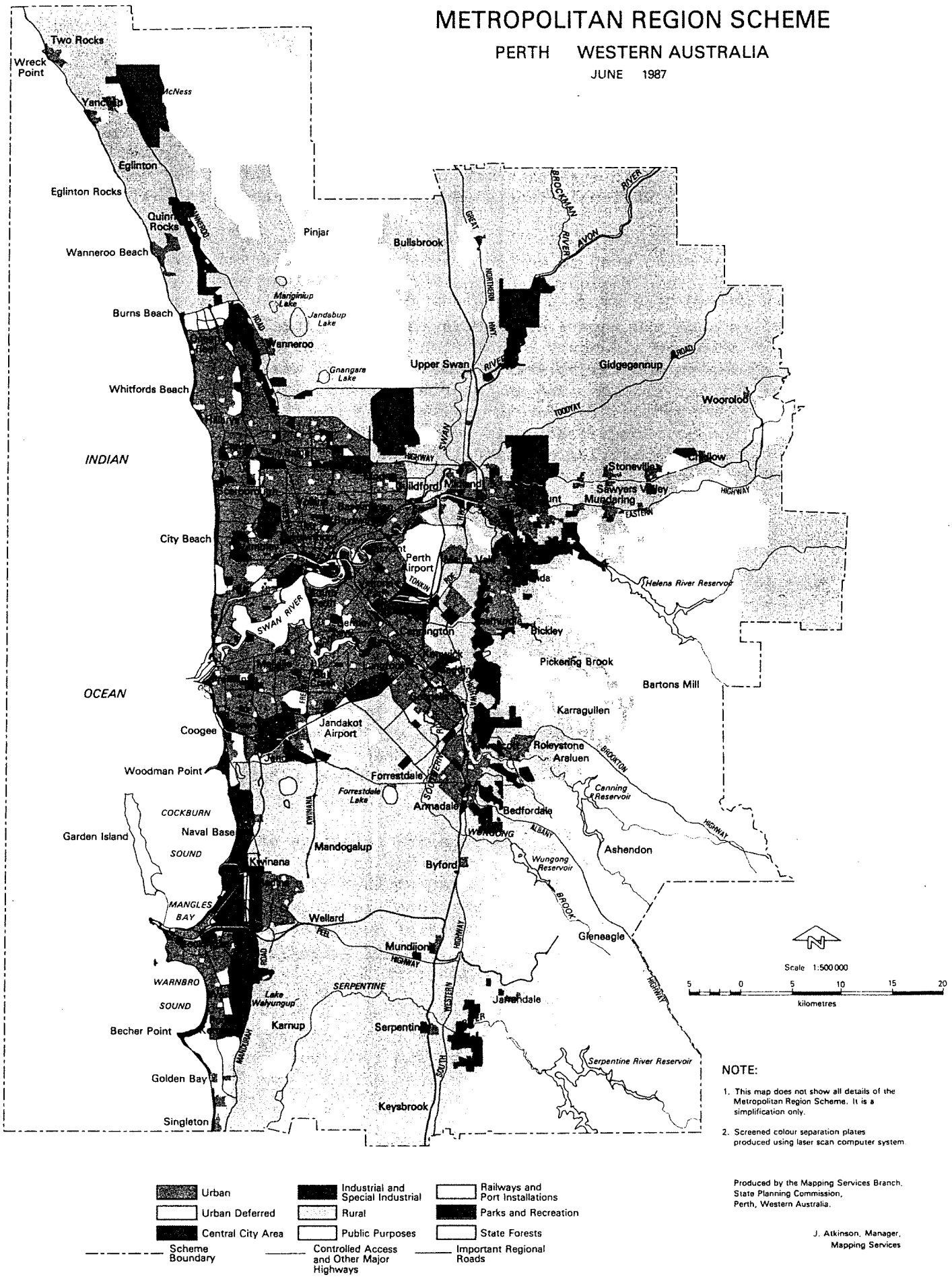

Figure 2. Metropolitan Region Scheme 1987.

REGIONAL PLANNING AS A POLICY

REGIONAL PLANS

The concept of Regional Planning as a policy of state and local government is another option that needs examination. As the wetland crisis extends way beyond the Metropolitan Area this may be the only alternative for country areas. The Bunbury Regional Plan is perhaps the best example to use (Fig 3).

Originating in 1966, when an ad hoc committee met to discuss some traffic bypass systems, this region was extended to cover all or parts of the districts of the City of Bunbury and the Shires of Harvey, Dardanup and Capel and is some 650 square kilometres in extent. The Town Planning Department prepared a Bunbury Region Plan in 1972. However, as this had no supporting report and was primarily a road plan, it was found necessary to undertake further studies, and an interim report was prepared in 1980. This resulted in two options for future growth being identified and published for community comment. Consideration of submissions and further investigations resulted in the preparation of a final Region Plan in early 1987, with the recommendation that:

- The Bunbury Region Plan be adopted as a Statement of Planning Policy under Section 5AA of the Town Planning and Development Act, and;

- matters relating to implementation, funding and review be the subject of further investigation.

ENVIRONMENTAL PROTECTION

The Plan, and the documentation are very different to the Statutory Region Scheme, and illustrate the inherent problem in implementing a regional plan without the statutory back up that an Act of Parliament can bring. More positively, however, such a plan can illustrate the spirit of cooperation and endeavour put in by local government to achieve a co-ordinated regional infrastructure.

Clearly in the first instance, the problems relate to natural environmental protection. In the case of this subject, how can the wetlands that are privately owned be protected and managed without any funds for compensation or land purchase other than those from local government? As a result, the major wetlands away from the urban areas of Australind, Eaton and Bunbury are labelled as "Areas under consideration for conservation scenic protection and reservation" on the Plan (Fig 3.)

Even though local and state governments may oppose destruction of these environmentally sensitive areas, there is little, if any, statutory control outside the local Town Planning Scheme, and local government is reluctant to reserve land in local town planning schemes unless funds are available for compensation or purchase.

It is as a result that the two recommendations relating to the Statement of Planning Policy, and implementation were made above. Before discussing these, we should look at the positive aspects of this region plan. It has been prepared by local government - technical staff and elected representatives - over an extended period of time. It is generally an agreed plan with each local government, and the state government being aware of its (the plan's) limitations.

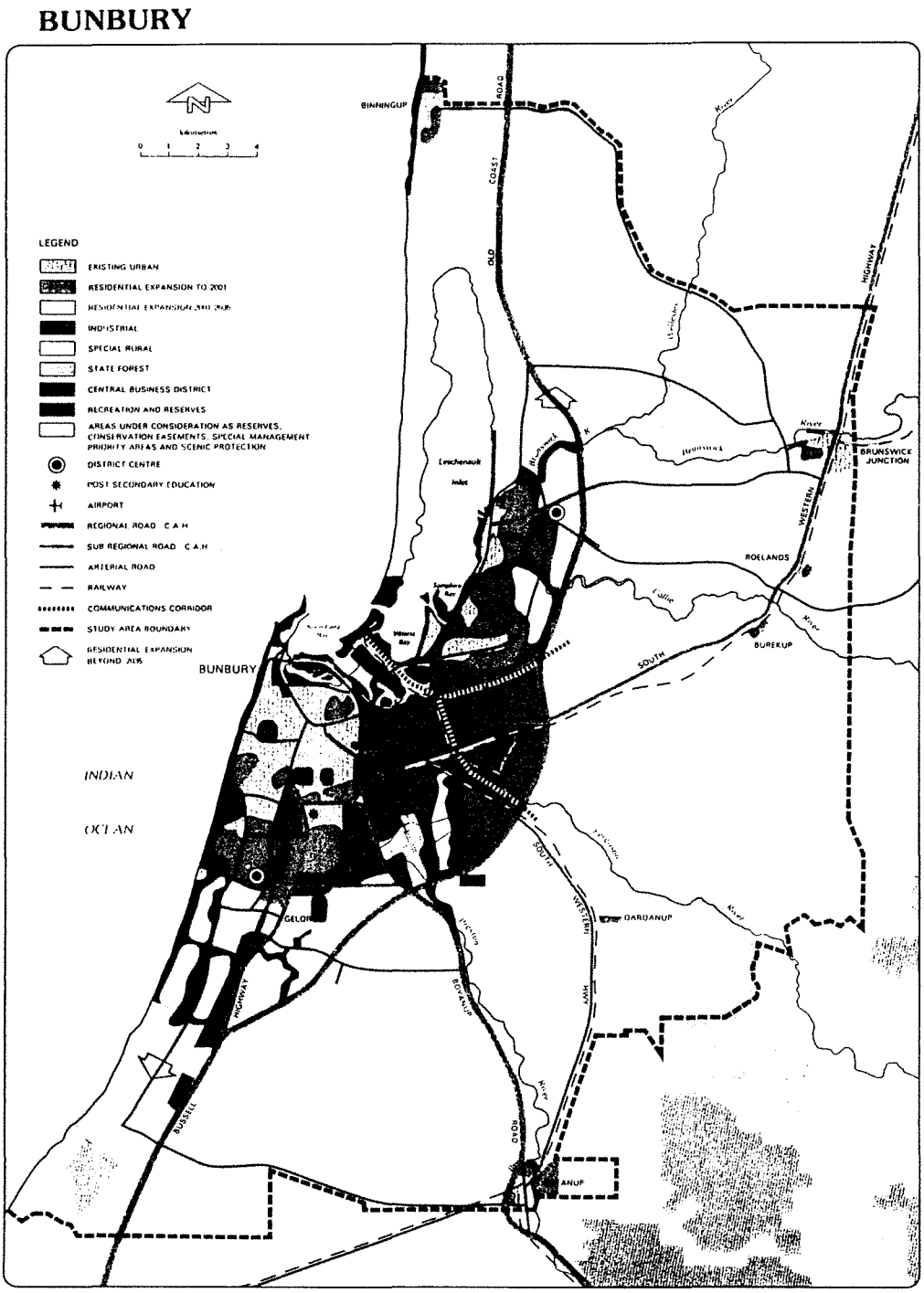

Figure 3. Bunbury Region Plan Option A of the 1982 Proposal.

As a result, one can be reasonably confident that local government town planning schemes will reflect the region plan as far as finances permit.

However, if a local government chose to ignore the provisions and policy statements when considering development, there are no enforcement provisions. Further, there is no way of controlling the initiation of local scheme amendments to comply with the Region Policy.

STATEMENT OF PLANNING POLICY

Clause 5AA of the Town Planning and Development Act allows for the preparation of a "Statement of Planning Policy", which may make provision for any matter which may be the subject of a Town Planning Scheme, but which shall be directed primarily towards broad general planning and facilitating the co-ordination of planning throughout the State by all local government. Therefore, this Clause is seen as one means of achieving some statutory backing without having a separate Act.

The Act states that, in the preparation of a statement of planning policy, the Commission shall have regard to:

(a) demographic, social and economic factors and influences;

(b) conservation of natural resources for social, economic, environmental, ecological and scientific purposes;

(c) characteristics of land;

(d) characteristics and disposition of land use;

(e) amenity and environment;

(f) communications; and

(g) developmental requirements of public authorities.

It is therefore broad enough to cover the wetland areas, and to emphasise the environmental, ecological and scientific significance of these.

The important aspect of a Statement of Planning Policy is the fact that it gets formal approval by the Governor, meaning it has full support from the State Government. Clause 7 (5) (a) of the Act, states that every local authority in preparing or amending a town planning scheme "shall have due regard to any approved statement of planning policy prepare under Section 5AA of this Act which affects its district," and at Section 53 of the Act states in describing the Town Planning Appeals tribunal "In determining any appeal, the Appeal Tribunal shall have due regard to any approved statement of planning policy, prepared pursuant to the provisions of Section 5AA ff this act which may affect the subject matter of the appeal."

So there is some statutory base on which to encourage protection of wetlands, but no financial base. Hence, the need to further examine the funding context of regional plans.

FUNDING

In this context, and to move away from Bunbury, the Shark Bay Regional Planning Study Team set out with the intention of closely examining the basis on which a statutory scheme, somewhat similar in structure to the Metropolitan Region Scheme could be implemented in the Shark Bay Region (Fig 4). Although no final decision has been made, they examined:

. a land tax similar to the Metropolitan Region improvement tax, and;

. a visitor or tourist tax - as the Shark Bay area is a tourist destination the "user pays" principle was examined. No formal decision has been made on these options, but it could be crucial to the success of the plan.

SUMMARY

To summarise the statutory and non-statutory regional plans in relation to wetland protection and local government, it can be stated that:

. Regional Planning is important in co-ordinating and rationalising protective measures, such as reserves and development control for wetland areas.

. Local Governments must participate positively in the preparation and maintenance of regional plans.

. Separate funding mechanisms are necessary if regional protection of wetlands is going to work successfully.

. A statutory scheme, like the Metropolitan Region Scheme, is much more effective than a non-statutory scheme.

. Ongoing management of wetlands once in state ownership needs further input.

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State Planning Commission (1988)

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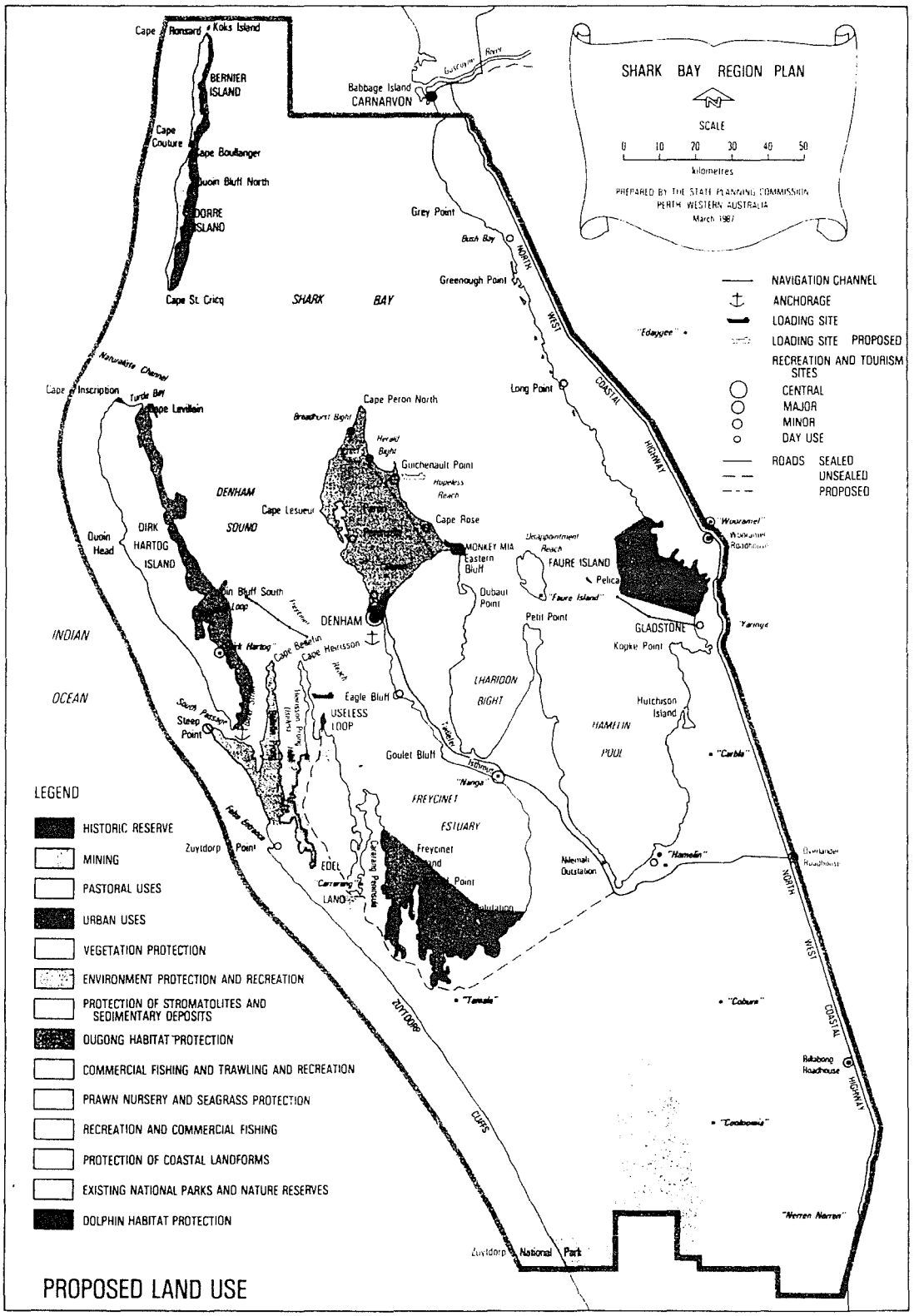

Figure 4. Shark Bay Region Plan Recommendation.

WETLANDS AND LOCAL PLANNING

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ABSTRACT

The City of Cockburn contains a significant number of formal and informal wetlands.The formal wetlands are those clearly defined in two western and eastern linear chains. The western chain comprises Manning Lake and Lake Coogee and the eastern chain includes Bibra Lake, Yangebup Lake and Thomsons Lake.The informal wetlands are characterised by those areas of high watertable confined to the south-eastern sector of the district.

The wetlands have a significant influence on the development and land-use patterns of the area.

Wetlands should be retained where possible in an endeavour to preserve remnants of the natural environment within urban areas. At the same time, however, wetlands within an urban setting should perform a drainage, recreational and aesthetic function. It is difficult to see how wetlands in this situation can be retained in their natural state.

The Council has had experience in dealing with wetland issues in respect to urban and rural development. This has resulted in the adoption of scheme provisions, the formulation of policies and the establishment of, and involvement in, steering committees.

The significant wetlands in the City of Cockburn are not in crisis based on the protection that is likely to be afforded to the formal wetlands as a result of the System 6 recommendations and the Beeliar Regional Park proposals. However, the informal wetlands which are located mainly within rural land are subject to development pressures.

There are a number of actions local government authorities can take to conserve and protect significant wetlands:

(1) Recognise the importance of wetlands to their district.

(2) Identify wetlands that are or will be under development pressure and attempt to determine their ultimate function and value to the community.

(3) Make provisions in their Town Planning Schemes.

(4) Define conservation precincts.

(5) Pass preservation or conservation resolutions.

(6) Formulate policies.

(7) Establish steering committees.

In conclusion, planning is by nature a process of compromises. The planning and development of wetland areas is no exception.

It is important that wetland conservation, development, community values and expectations are brought together to ensure that the environment on which we depend for our survival and wellbeing is not lost to development and that the development on which we rely for our living is not minimised by the need to preserve the natural environment.

The key to this complex issue is to apply solutions which allow for wetlands and urban areas to coexist in a mutually beneficial relationship.

INTRODUCTION

The district of the City of Cockburn contains a significant number of wetlands both formal and informal (Figures 1, 2 and 5).

The formal wetlands exist in two clearly-defined north-south chains.

The westerly chain extends from Manning Lake in Hamilton Hill in the north, southwards to include the Market Garden Swamp, Lake Coogee and Brownman Swamp in Henderson, a distance of around 9 kilometres.

The easterly chain extends from North Lake, near the Murdoch University, southwards to include Bibra Lake, South Lake, Little Rush Lake, Yangebup Lake, Kogolup Lake, Thomson Lake and Banganup Lake in Wattleup, a distance of about 11 kilometres.

Most of these water bodies are significant, in that Lake Coogee and Bibra Lake for example are both 1.5 kilometres long, Yangebup Lake is approximately 1 kilometre in diameter and Thomsons Lake, the largest of them all, is in excess of 1.5 kilometres in diameter.

THE WESTERN CHAIN

The western chain is not as strongly connected as the eastern chain.

The western chain has a major break between Manning Lake and the Market Garden Swamps by an elevated railway line and a 2 kilometre wide stretch of semi-rural development. Manning Lake therefore is not perceived to be part of the western chain. The Market Garden Swamps are a clearly defined wetland and drainage system which flow into Lake Coogee. Lake Coogee connects to Brownman Swamp via a series of recognisable wetland areas located within market gardens.

THE EASTERN CHAIN

The eastern chain is quite different from the western chain in that it is clearly defined and recognised by the public as a contiguous wetland system. This is particularly true of the northern sector which is traversed by Forrest Road.

Moreover, the majority of the wetlands in this chain are protected by either regional reservation or by State conservation and fauna reserves. It is only a small section between Yangebup and Thomsons Lakes which is not reserved. However, this is proposed to be overcome by virtue of creating a Regional Park to encompass the wetlands, known as the Beeliar Regional Park.

WETLAND PROTECTION

The formal wetlands are or will be protected by regional or local reservations, the Beelair Regional Park proposals and of course the System 6 recommendations (Figures 3 and 4).

The informal wetlands exist primarily in the south-eastern sector of the district where the watertable is high and the land is flat. The majority of the area is zoned rural under both the Region Scheme and the Local Authority Scheme, and is in private ownership. Therefore the level of protection of the wetlands is minimal.

DISTRICT CONTEXT

The western wetland chain forms an integral and complementary part of the dominant limestone ridge which runs parallel and adjacent to the coast for the total length of the district. The inherent features of this section of the metropolitan coast set it apart from areas to its north and south. It is imperative that these features be conserved as part of the future development of the coastal areas.

The eastern wetland chain is a significant development barrier, which bisects the district into two distinct parts. The barrier represents not only a planning edge which influences the pattern of urban and community development, but also the transition between the physical characteristics of the district, namely soil and stone types, vegetation and landform. It can be seen therefore, that the wetlands form a significant part of the City of Cockburn.

PLANNING IMPLICATIONS

At the outset of the discussions relating to what Councils can do to play their part in the conservation and protection of wetlands within both urban and rural areas, I would stress that the philosophy towards the "highest and best use" of land promoted by Ian McHarg in his book "Design with Nature" (McHarg, 1971), is a most appropriate and desirable approach.

In other words, the land most suited for development should be identified and separated from those areas which are less suitable.

This approach, if applied at a regional planning scale, could potentially achieve two important needs namely:

1. The conservation of important wetlands.

2. The ability to differentiate one residential area from another, by capitalising on natural features. In Perth I see this as important, not only from a visual and environmental viewpoint, but also from a marketing aspect, given the monotonous sprawl of the suburbs which are in the large part devoid of natural landmarks.

At the same time, however, it must be remembered that the wetlands in the metropolitan area are being and will be surrounded by urban development, and as such should be treated as urbanised wetlands and not protected in their natural state as if they were in a wilderness area.

Wetlands in the urban areas must function as part of the metropolis and be available for use as drainage systems and as areas of passive open space.

Where possible, the remnant fringing vegetation should be retained and significant habitats protected and, if appropriate, the margins behind parkland cleared and grassed for public access.

In future urban areas affected by wetlands, the old adage "site sensitive" planning becomes a meaningful benchmark for the design and development of these areas.

The need for conservation, development, function and usage, will therefore always be a compromise.

CASE STUDIES

In an endeavour to illustrate the range of development versus wetland issues, experienced to date within the City, four case studies have been selected relating to urban, special rural and rural situations.

1. Packham Development Area (Figures 6 and 7)

This development area has a long history, which has in the large part revolved around the problems of drainage.

As a result of a recent initiative by a firm of private consultants, the redevelopment of this 'urban deferred' land from market gardens to residential allotments has been resurrected after remaining dormant for many years.

In an endeavour to identify the problems, needs and possibilities of the Market Garden Swamps, the Council, at the request of the Consultants, established the Wetlands Technical Steering Committee with representatives from the consultants, the Council, the Department of Conservation and Land Management, Environmental Protection Authority, Water Authority of Western Australia, State Planning Commission and a local developer. The first meeting was held in January 1987.

Based on the deliberations of the Committee, indicative plans were produced showing how the wetlands could be retained, utilised and, where appropriate, modified to function as a combined drainage and open space system.

Today the detailed plans are being finalised which provide for the retention of the Market Garden Swamps in the context of the recommendations of System 6, (Department of Conservation and Environment, 1983) the Beeliar Regional Park (State Planning Commission, 1986) proposals and the requirements of all the parties involved.

Initiatives have now been taken to lift the urban deferment and to amend the local Scheme accordingly.

2. Thomsons Lake Urban Study Area (Figures 8 and 9)

In 1986, the State Planning Commission (SPC) published a report (State Planning Commission, 1986) showing a major extension to the metropolitan urban area east of Thomsons Lake to accommodate around 25,000 people at traditional residential densities. This was a major revision to the Strategy for the south-west corridor produced by the Department in 1980.

This decision brought into focus a complex interrelationship of drainage, water management, conservation and development issues.

Urban development reduces groundwater recharge as it causes water to be transported into and from important conservation water bodies. In turn, these water bodies place an impediment on development. These conflicts create problems for regional water management strategies for which long-term solutions are seen to be required by some for all of these issues prior to the initiation of any rezoning.

Needless to say, a number of the issues appear unreconcilable and an impasse has occurred.

The situation has developed into a political, economic and development issue well beyond the scope of the Council. The Council is only one small player in the formulation of a likely outcome.

However, to demonstrate the influence of the Council on the proposals for subdividing the higher and drier north-western sector of the structure plan, which is largely owned by a single development company, the Council, prior to the Environmental Protection Authority and the Water Authority of Western Australia becoming involved, negotiated the possible retention of the "Twin Bartram Swamp" as part of the open space contribution.

To enable this to occur, instead of being redeveloped as a primary school site and sump as initially proposed, the Council agreed to recommend to the SPC that the wetland area, which is about 12 hectares, be not only deducted from the developable area over which the 10% public open space is calculated, but also be credited as public open space for 50% of the area involved.

Based on this, and the argument that the wetland should form part of the stormwater drainage system, and that the filling and draining of the land to create a limited number of building lots could be costly, there may be an economic advantage to the developer in retaining this wetland area.

Although the Council envisaged that the wetlands may be modified for drainage purposes, where possible the fringing vegetation should be retained and the margins developed for passive and perhaps some active recreation areas.

Moreover, the wetland would become a "feature" of the subdivision.

Unfortunately, at this time the drainage and conservation issues relating to the development of the area have not been resolved, and therefore the potential of this initiative has not been realised.

The ability to keep the incidental wetlands such as "Twin Bartram" and to drain the areas to the south and east for urban development, appears slim based on current advice. By virtue of this, a decision will need to be made between the value of the wetlands for conservation, and the need to create serviced allotments in the south-west corridor, the supply of which has now become critical.

Despite the Council's involvement, a decision will no doubt be made by the Government to reconcile these issues.

3. Special Rural Development (Figures 10 and 11)

This form of development, has, over recent years been a popular re-use of inefficient and depleted farmland. Owners, after going through the less-than-rigorous steps of rezoning, are able to convert acreage into 2 hectare lots (State Planning Commission, 1987).

In Cockburn, these subdivisions are occurring in the eastern sector of the district, particularly south of Forrest Road on an area characterised by a high watertable and informal wetlands (City of Cockburn, 1987).

Plans approved in the past excised the wetlands as Public Open Space, but because of the inability by the public to easily use these areas and the difficulties of maintenance, the Council now prefers to wetlands to be included in private allotments with restrictions to protect them from development.

Because Special Rural Zone subdivision and development is preceded by rezoning under the Council Scheme, the Council is in a strong position to require not only a variety of information in support of the proposal, but is also able to apply a range of design and development conditions.

It should be noted that there is no right of appeal to a refusal to rezone.

Conditions such as building envelopes, tree clearance controls, land-use restrictions and wetland protection can be applied.

In fact, the creation of Special Rural Zones provides an opportunity to conserve and protect wetlands without a cost to the community or a hardship on the landowner.

The Council's District Zoning Scheme No. 1 (City of Cockburn, 1974), requires, in respect of wetlands in Special Rural Zones, the following:-

"48A (a) (iii) The retention of all-year wetlands

(b) (iii) A plan or plans showing contours at such intervals as to adequately depict the land form of the area and physical features such as existing buildings, rock outcrops, trees or groups of trees, lakes, swamps, orchards, wells and significant improvements.

(b) (v) (3) Those physical features it is intended to conserve.

(5) Highest known groundwater levels as certified by the subdivider's drainage engineer, on the basis of advice from the Metropolitan Water Authority."

These provisions have formed part of the Scheme since 1984.

The Council's proposed Scheme No. 2 (City of Cockburn, 1986), is more general, so that it can provide the scope to deal with most aspects relating to both the physical and the built environment within these zones in the future.

In addition the Statutory Scheme provisions, the Council has adopted policies such as:

"POLICY - DEVELOPABLE AREAS WITHIN ALLOTMENTS IN SPECIAL RURAL ZONES"

The Council in considering an application for a Special Rural Zone will require the applicant to:

(1) provide the Council with a plan at a scale of not less than 1:2000 of the land showing the existing contours at 1.0 metre intervals or less and also including a contour of the highest known groundwater table issued or agreed to by the Water Authority of Western Australia;

(2) include within each proposed allotment an area of at least 1500m^2 of developable land located above the highest known or potential groundwater table, referred to as the "dry land";

(3) locate a building envelope on each lot with a minimum area of 1000m^2 and a maximum area of 2500m^2 with a minimum dimension of 20 metres within which the maximum area of "dry land" is to be contained;

(4) locate the building envelope no closer than 20 metres to a road frontage and no closer than 10 metres to all other boundaries of the lot;

(5) upgrade all existing roads and to construct all new roads at a height of at least 1.2 metres above the highest known or potential groundwater table; and

(6) restrict all clearing, filling and building, within the building envelope on each lot unless the Council has granted its special consent to do otherwise."

This policy was adopted by the Council in December 1986.

"POLICY - REQUIREMENTS FOR SPECIAL RURAL ZONE PROPOSALS"

Applicants seeking to rezone land to Special Rural shall provide the Council with details relating to the following:-

1. Reason for the application;

2. Purpose of the proposed zone;

3. Locality Plan;

4. Full description of the subject land and ownership;

5. Existing site information -

   . Contours
   . Vegetation
   . Natural Features
   . Soils
   . Water Table (highest known)
   . Improvements
   . Adjoining Roads and Services
   . Relationship to adjoining properties;

6. Site Analysis for development suitability;

7. Subdivision design;

8. Building envelopes;

9. Landscape and wetland protection areas; and

10. Land management controls and water supply.

This information should be in the form of a short report and include comments and/or information from the Water Authority of Western Australia, the Department of Conservation and Environment, the Public Health Department and the Department of Agriculture as to the suitability of the land for development and use."

This policy was adopted by the Council in February 1987.

These policies evolved from the experience gained from the use and development of existing Special Rural Zone properties.

RURAL LAND (FIGURE 12)

Wetlands in the Rural Zone have virtually no protection and could be readily absorbed into expanded grazing or cropping areas. The clearing and filling of farm land has commonly been accepted as the right of the landowner to make the land more efficient and productive.

Wise landowners have developed their land in sympathy with the physical environment, using the natural systems to advantage. Other owners have tended to clear and fill, which has resulted in drainage and salinity problems, erosion and management difficulties. It is commonly these properties that become unviable and pressure follows to convert them into special rural lots.

Recently the Council experienced *ad hoc* and illegal filling of some land in the rural zone. As the land was not affected by a reserve or the System 6 area, there was little that could be done.

Moreover, the owners of these wetland rural lots were earthmoving contractors who planned to progressively fill the land. The incentive for the owners to do this, presumably, is that it is probably cheaper than paying tip fees which have increased markedly.

In these cases, the paperbarks have been cleared, despite the fact that the filling has ceased while awaiting Council approval to continue.

A conditional approval was issued. At the same time the Council adopted the following policy in April this year to assist in the protection of wetlands, particularly in the Rural zone, namely:-

"POLICY - PROTECTION OF WETLANDS"

The Council recognises the environmental and drainage significance of the wetlands within the district and believes that where possible such areas should be protected from development.

Where the landowner seeks the Council's approval to fill in or use an existing wetland it will be necessary for the applicant to demonstrate to the Council's satisfaction that the proposed filling, modification or use of the wetland will not have an adverse effect on the environment or the amenity of the locality and will not have a detrimental effect on the existing water levels and drainage of adjoining and nearby properties.

All applications to fill wetlands shall be referred to the Environmental Protection Authority under Section 38 of the Environmental Protection Act for consideration."

MIDGE (FIGURE 13)

For many years, since the development of residential areas around North Lake, Bibra Lake and Lake Yangebup, the Council has received numerous complaints about the midge nuisance during summer months. The problem is at its worst when residents are keen to use their outdoor areas.

To minimise the effect of the midge, the Council applies poisons annually by aerial spraying. It is evident that the effectiveness of the poison is lessening.

Based on this, the complaints, the costs, and the unknown long term environmental effects of the poisons on the ecology of the wetlands, the Council decided to adopt the following policy in March 1987:-

"POLICY - RESIDENTIAL REZONING AND SUBDIVISION ADJOINING MIDGE INFESTED LAKES

The Council does not support the rezoning or subdivision of land for residential development within one kilometre of the edge of any lake in the district that is known to have a midge problem."

It appears, based on the dismissal of an appeal against the imposition of the Council's policy to a rezoning proposal by the Hon. Minister for Planning, the Council's concern has now been officially acknowledged.

WETLANDS IN CRISIS

Are the wetlands in the City of Cockburn in crisis?

In my opinion, they are not, particularly the formal wetland chains, because of the impending protection that will be afforded to them by System 6 and the Beeliar Regional Park.

This opinion is also based on the fact that some change in the use, function, and perhaps in some cases, the form of the wetlands does not constitute a crisis.

As far as the informal wetlands are concerned these will always be under pressure from urban and rural development, and their protection will largely be by negotiation.

WHAT CAN LOCAL AUTHORITIES DO? (FIGURE 14)

Firstly, it is important to recognise that Local Authorities in the large part react to, rather than initiate, development.

Reaction is, however, not necessarily negative.

Reaction to proposals by others can produce policy or even statutory controls that can provide positive benefits for the future.

This has already been illustrated in the case studies.

Councils do not have the financial and staff resources or the in-house expertise to undertake wetland studies with a view to formulating a conservation strategy or policy.

Councils can, however, do the following:

. Recognise the importance of wetlands as a natural resource, in terms of environmental and community values.

. Identify those wetlands which are likely to be under development pressures in the foreseeable future, and determine which wetlands are worthy of conserving, utilising and draining, using a general knowledge of the area, relevant reports and expert advice.

. Include general provisions within their Town Planning Schemes for the conservation and protection of wetlands.

. Prepare statutory plans, by way of their Town Planning Schemes which delineates areas within the district within which wetland conservation and protection measures apply to development.

. Pass a preservation and conservation resolution under the Heritage provisions of their Town Planning Scheme.

. Formulate policies to complement the general provisions contained in their Town Planning Schemes which could relate to the identification, assessment, development, usage, conservation, protection and management of wetlands within their district.

. Establish a Steering Committee comprising representatives of appropriate authorities and the community, to which development proposals are referred for consideration and comment.

Commonly, where such committees are operative, they make recommendations to the Council, for which the Council may have due regard, but the final decision rests with the Council.

CONCLUSION

I believe that planning is, by virtue, a process of compromises. The planning and development of wetlands is no exception.

It is important that wetland conservation, development, community values and expectations are brought together to ensure that the environment we all depend upon for our survival and well being is not lost to development and that the development on which we rely for our living is not minimised by the need to preserve the environment.

The key to this complex issue is to apply solutions which allow for wetlands and urban areas to co-exist in a mutually beneficial relationship.

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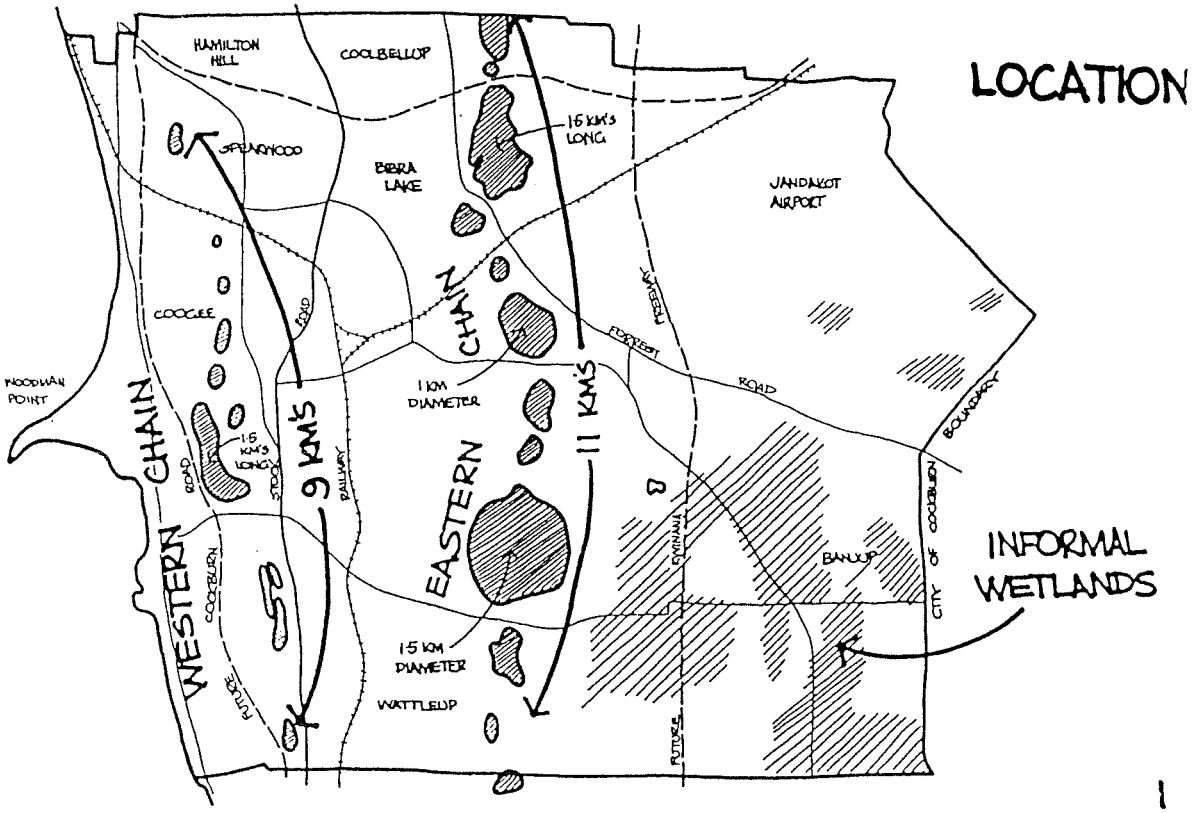
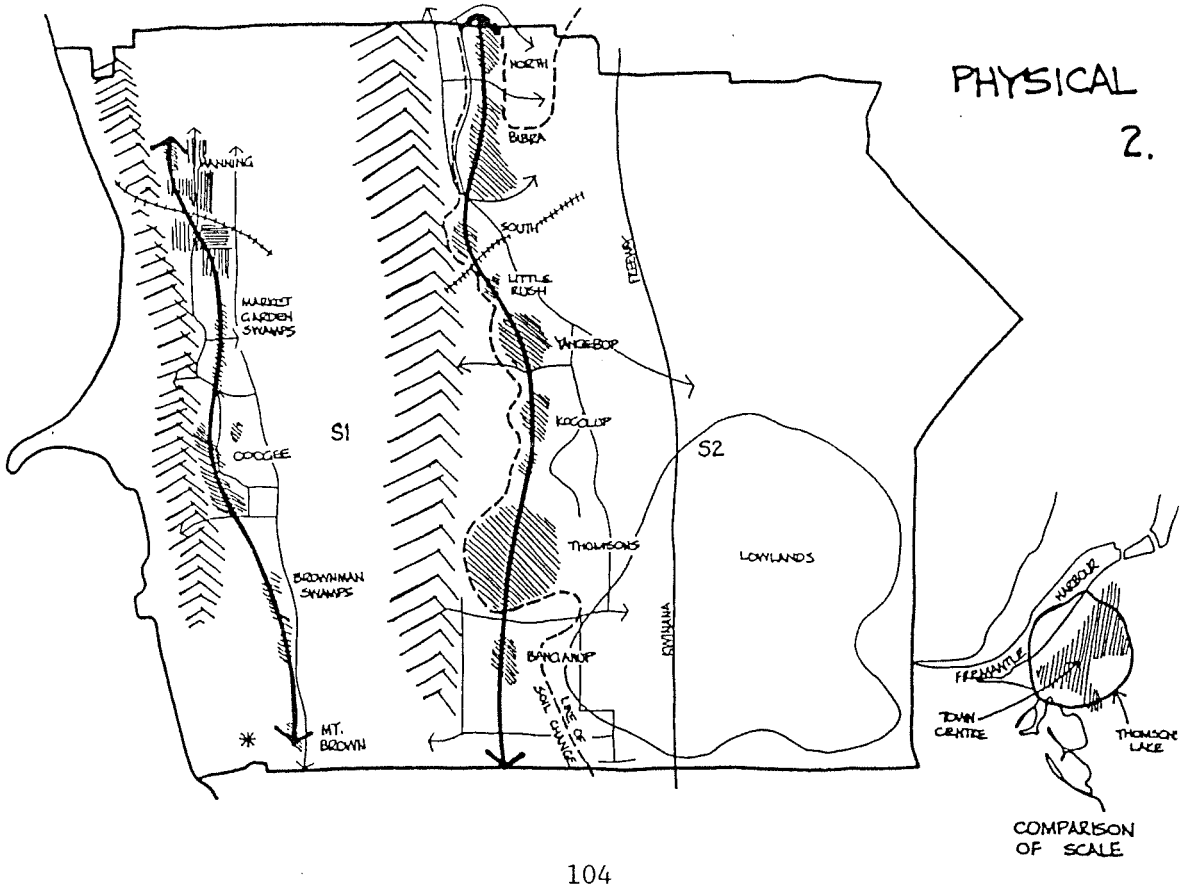
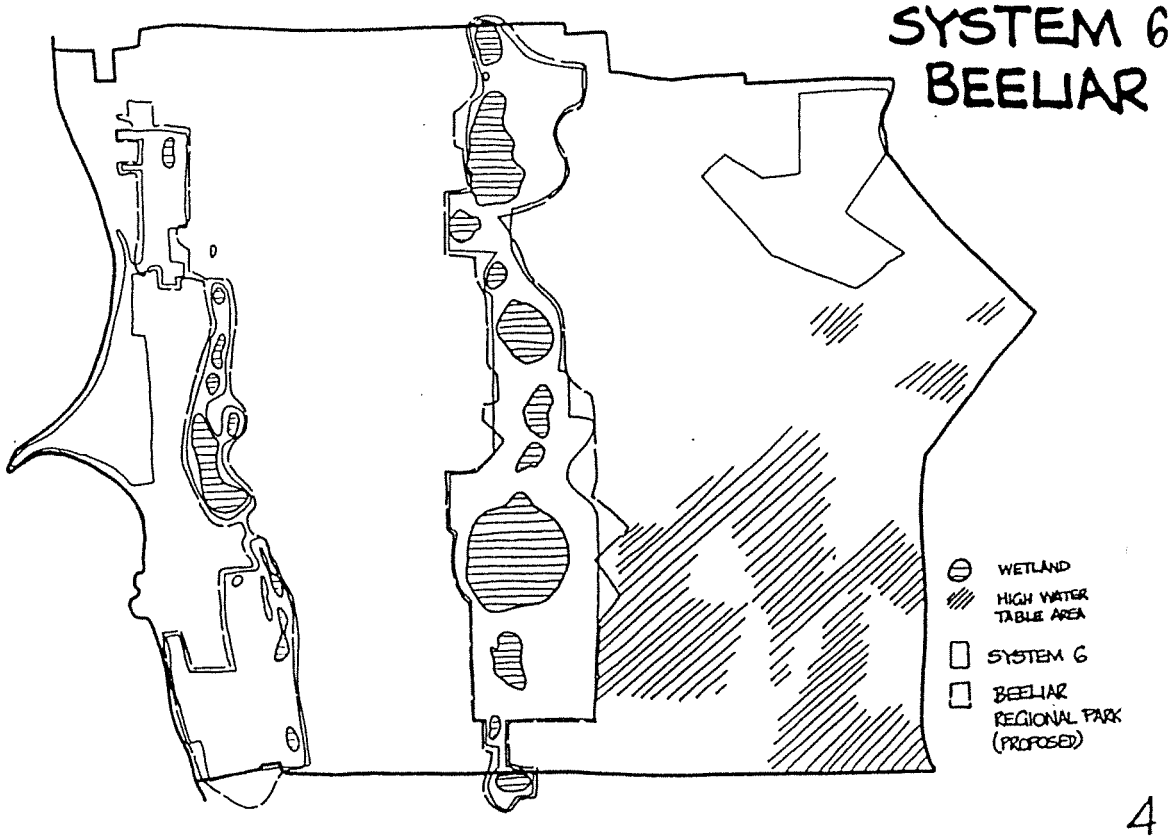

LOCATION
HAMILTON HILL
COOLBELLUP
SPEARWOOD
BIBRA LAKE
16 KM's LONG
JANDAKOT AIRPORT
COOGEE
WESTERN CHAIN
EASTERN CHAIN
9 KMs
11 KMs
1 KM DIAMETER
15 KM DIAMETER
WATTLEUP
BANJUP
INFORMAL WETLANDS
1


PHYSICAL
2.
NORTH
BIBRA
SOUTH
LITTLE RUSH
MARKET GARDEN SWAMPS
YANGEBUP
KOGOLUP
COOGEE
S1
S2
THOMSONS
LOWLANDS
BROWNMAN SWAMPS
BANJUP
MT. BROWN
LINE OF SOIL CHANGE
FREMANTLE
HARBOUR
TOWN CENTRE
THOMSON LAKE
COMPARISON OF SCALE

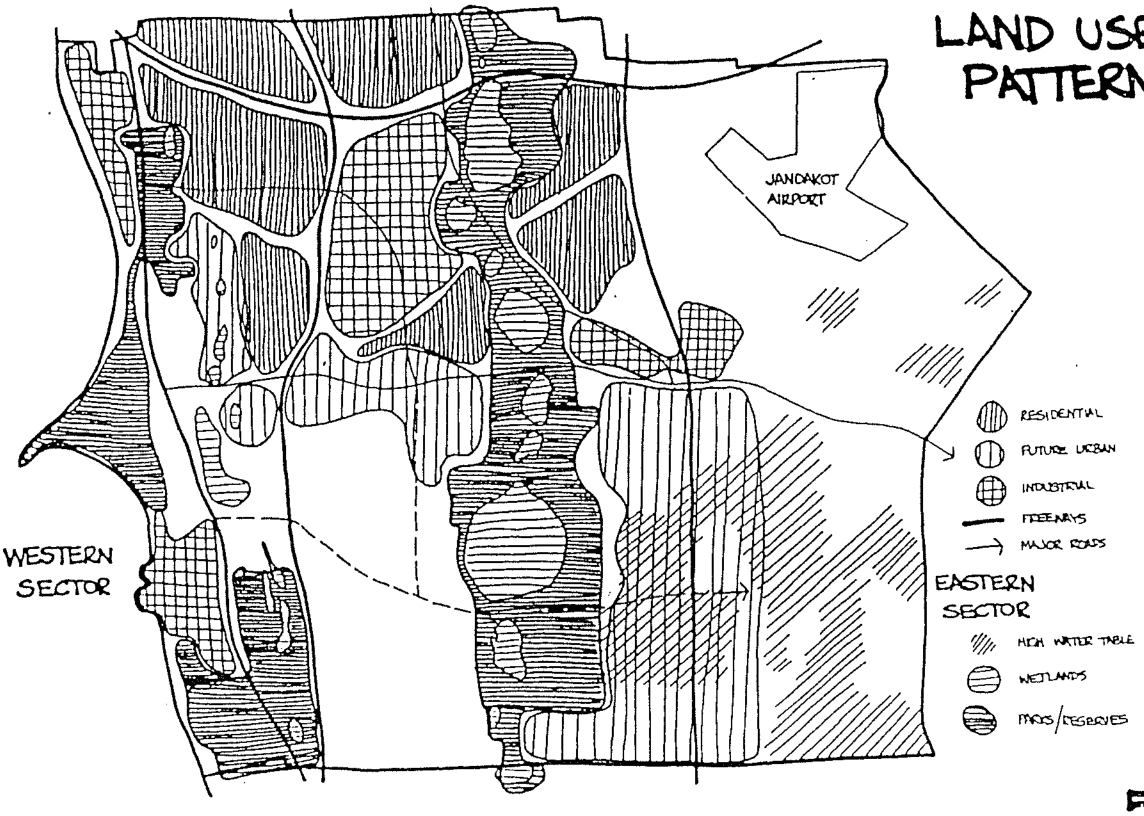

EXISTING
RESERVES

3


SYSTEM 6
BEELIAR
WETLAND
HIGH WATER TABLE AREA
SYSTEM 6
BEELIAR REGIONAL PARK (PROPOSED)

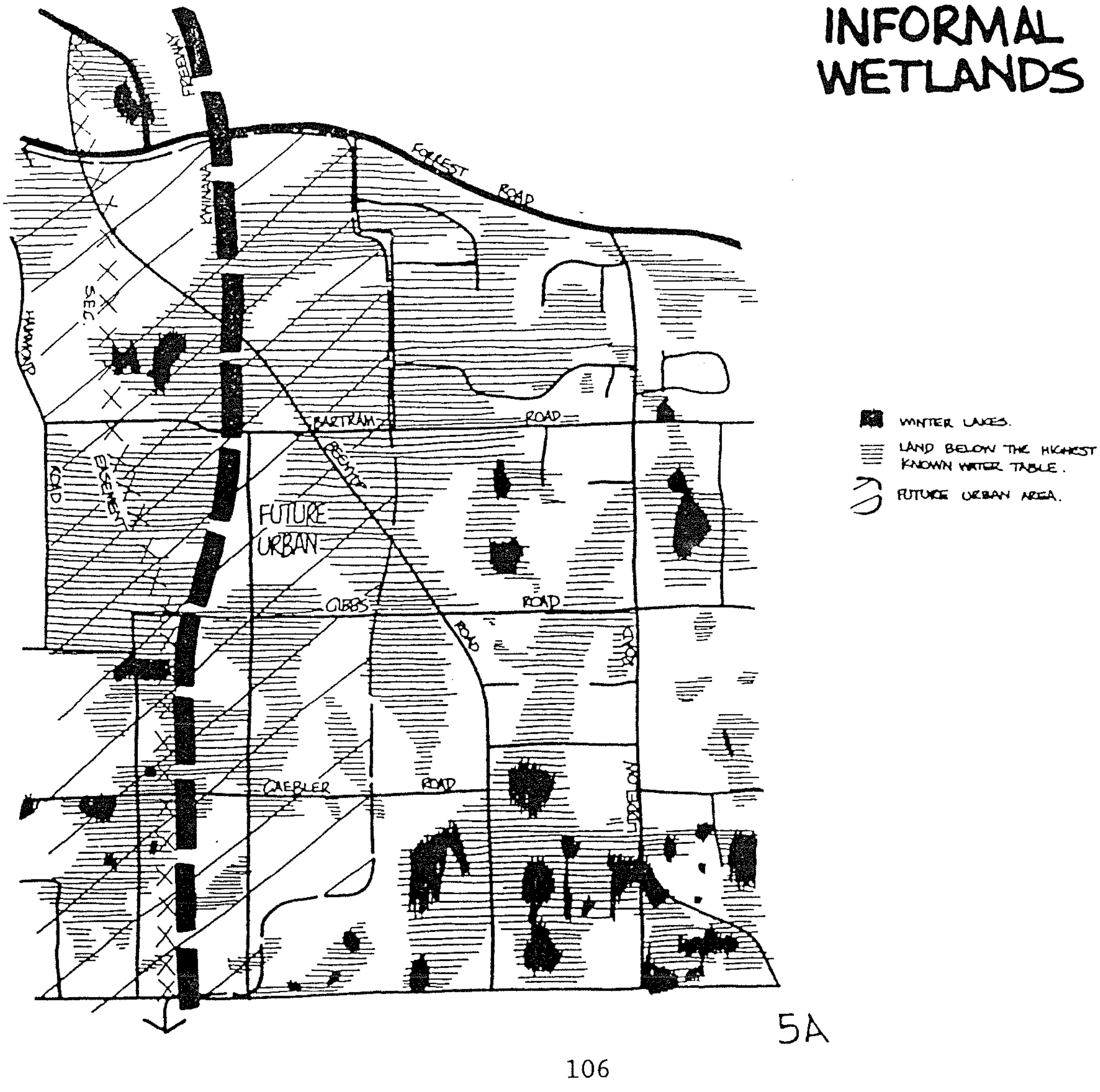
4

LAND USE PATTERN



5.

INFORMAL WETLANDS



5A

PACKHAM DEVELOPMENT AREA.

WETLANDS TECHNICAL STEERING COMMITTEE

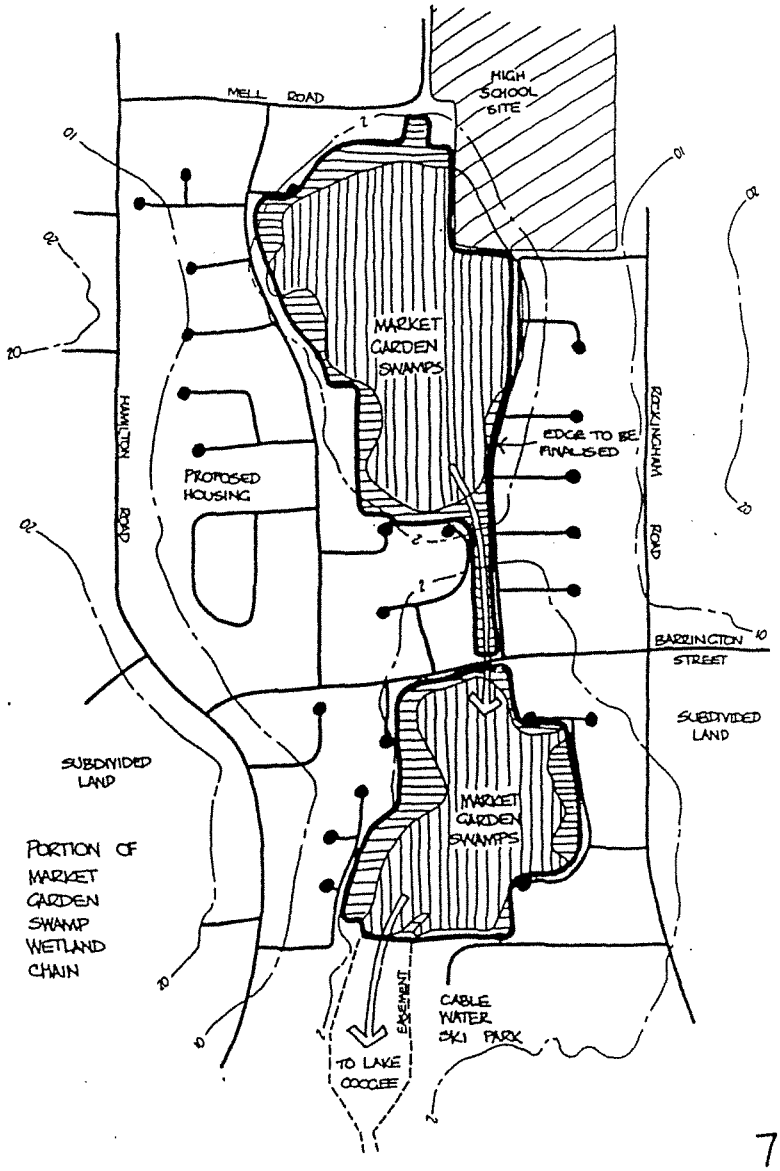
REPRESENTATIVES.

1. PROJECT MANAGEMENT CONSULTANT.
2. PROJECT ENGINEER.
3. C.A.L.M.
4. E.P.A.
5. W.A.W.A.
6. S.P.C.
7. CITY COUNCIL - CITY PLANNER
   - CITY ENGINEER.
8. LOCAL SUBDIVIDER / DEVELOPER.

FIRST MEETING. JANUARY 1987.

6

PACKHAM DEVELOPMENT AREA



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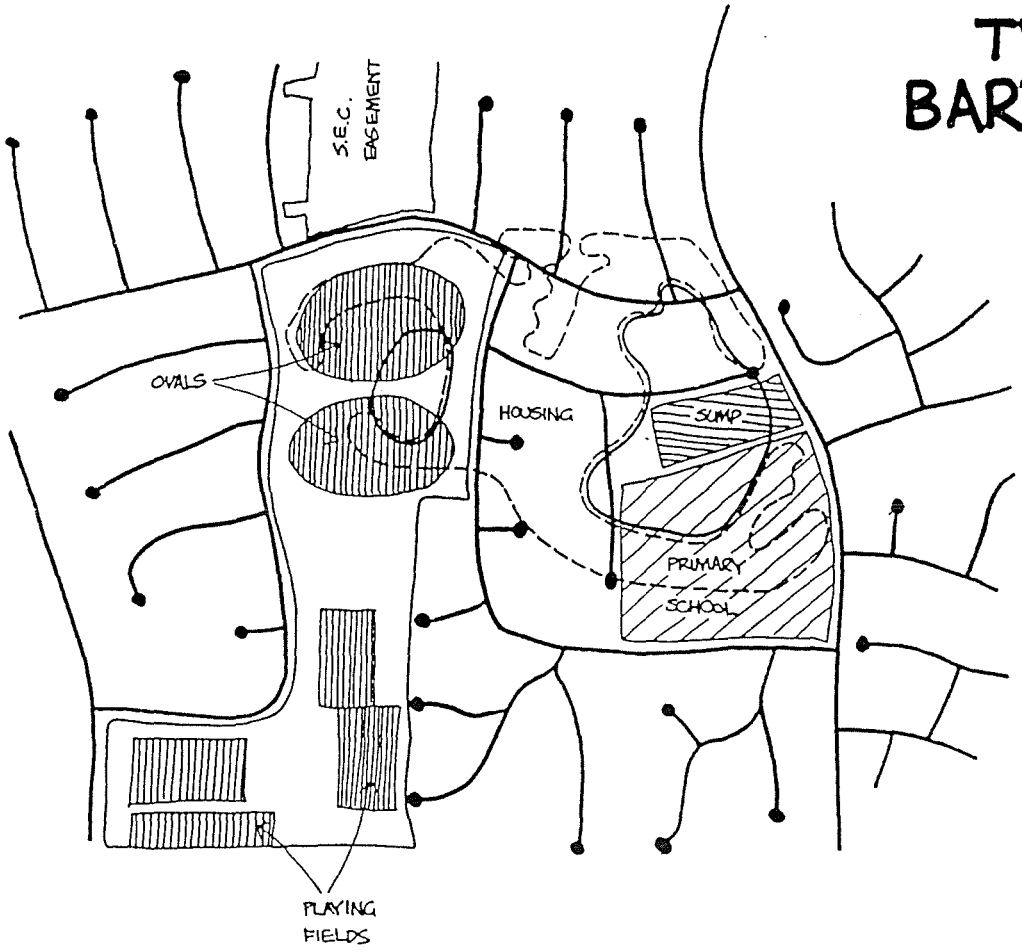
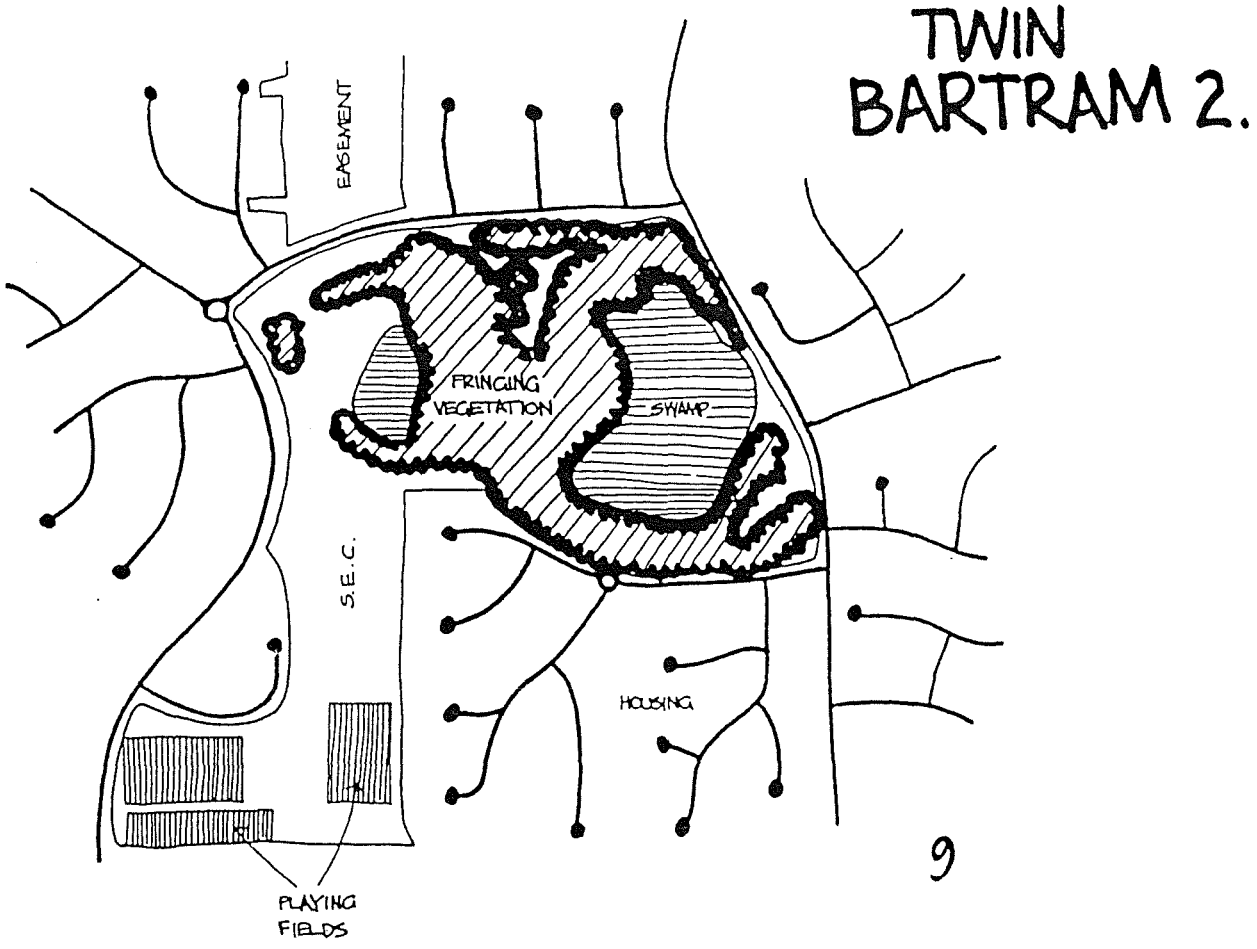
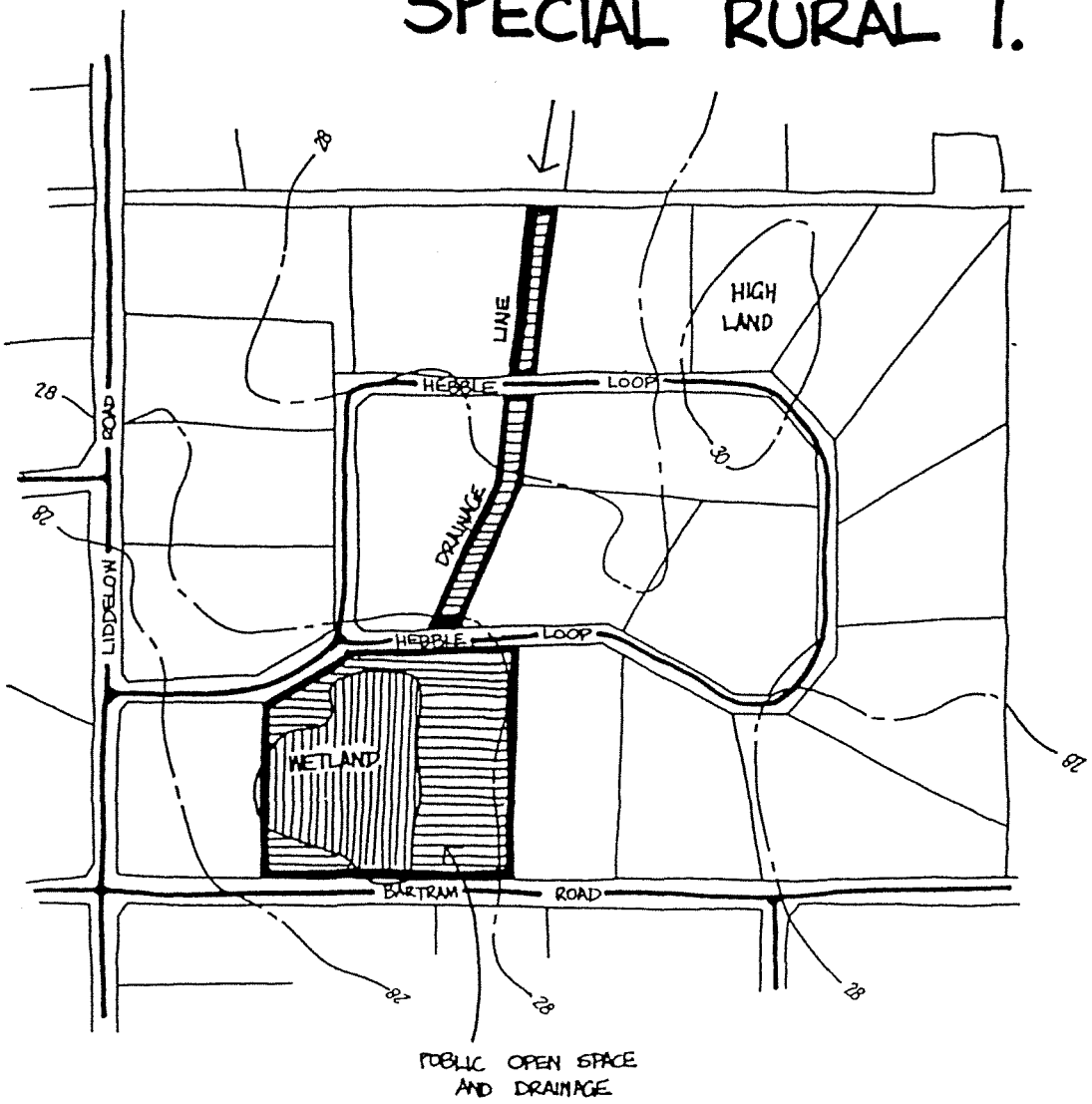

TWIN
BARTRAM 1.
S.E.C.
EASEMENT
OVALS
HOUSING
SUMP
PRIMARY
SCHOOL
PLAYING
FIELDS
8


TWIN
BARTRAM 2.
EASEMENT
FRINGING
VEGETATION
SWAMP
S.E.C.
HOUSING
PLAYING
FIELDS
9

SPECIAL RURAL 1.



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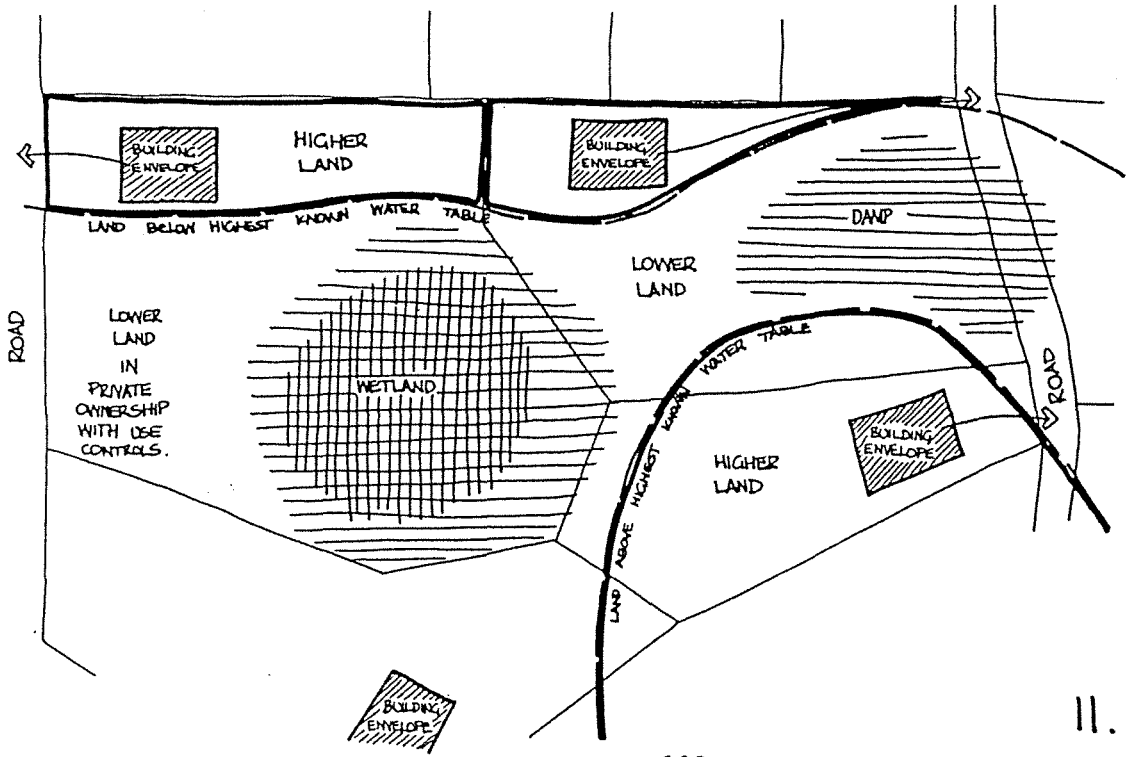
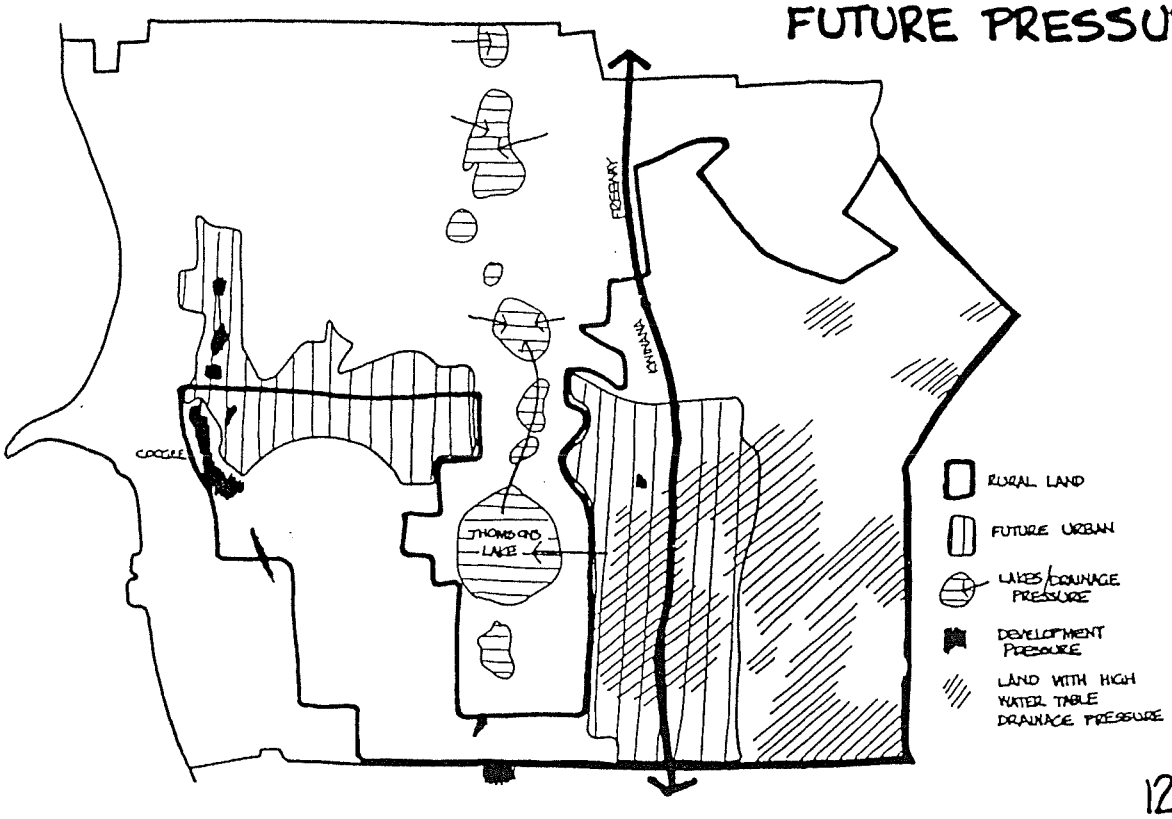
SPECIAL RURAL 2.



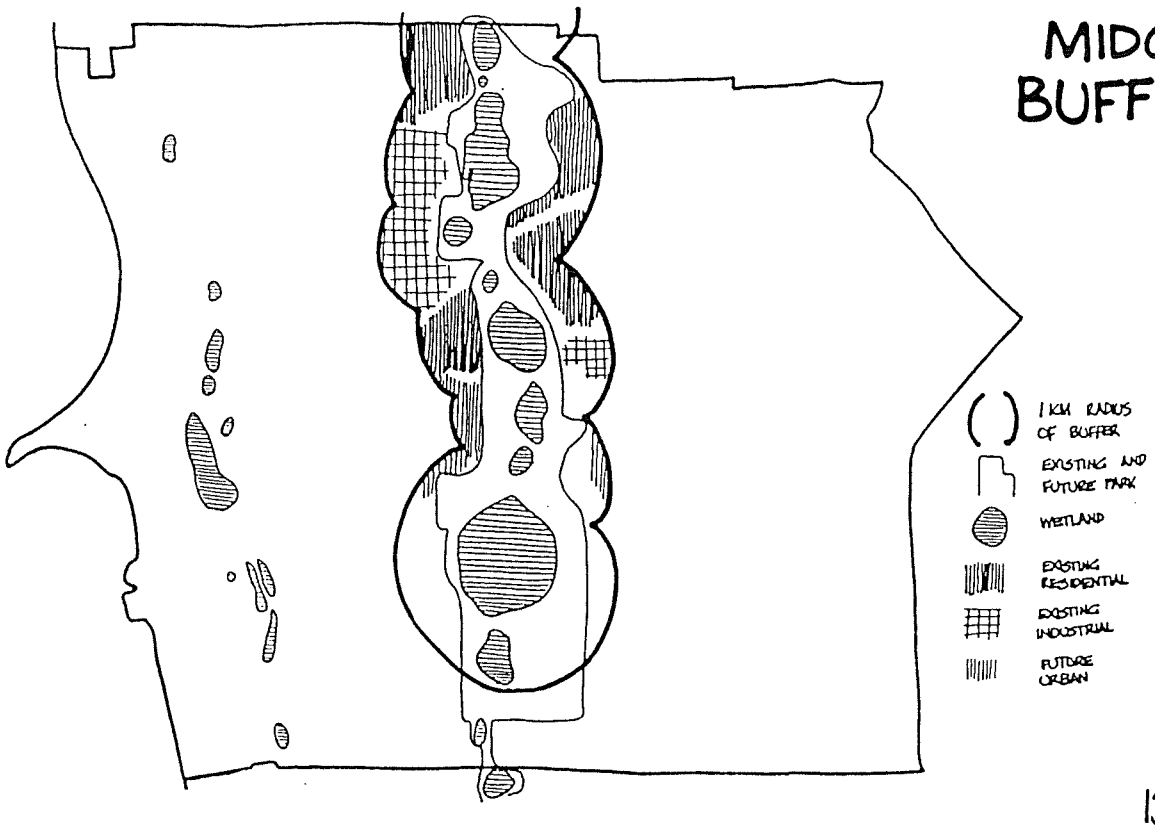
11.

RURAL LAND AND FUTURE PRESSURE



12.

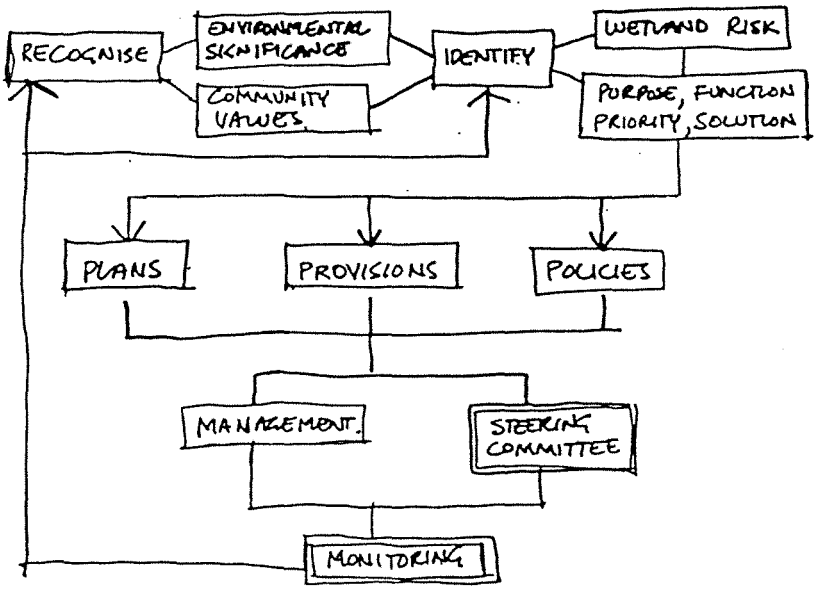
MIDGE BUFFER



13.

WHAT CAN LOCAL AUTHORITIES DO?

1. RECOGNITION.
2. IDENTIFICATION.
3. STATUTORY PROVISIONS.
4. PLANS.
5. RESOLUTIONS
6. POLICIES.
7. STEERING/MANAGEMENT COMMITTEES.



14

THE NEED FOR MANAGEMENT PLANS

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ABSTRACT

Most reserves in Western Australia are subject to management action in various forms. Individual problems are sometimes seen in isolation, using a specific information base in a local context, with little or no public input. The result is that solving one problem sometimes causes other problems. A management plan provides a broader framework within which these problems can be solved. It should provide an integrated summary of the resources of a reserve, how it works, how it fits into a regional framework, and how people feel about it. It defines objectives for future management, and provides co-ordinated guidelines for management of the reserve.

Management plans must be acceptable to the local community, if they are to be successful. Close liaison with the public, interest groups, local and State government is necessary. In addition, the implementation of the proposals must be monitored, and if necessary changed, to ensure that they achieve the desired objectives.

PUBLIC PARTICIPATION IN WETLAND MANAGEMENT : THE ROLE OF LOCAL GOVERNMENT

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Paul Richards
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Floreat Park, WA 6014

ABSTRACT

In a recent study of public attitudes towards groundwater and wetlands in the Jandakot area, we found a great deal of interest and knowledge about local wetland issues. Wetland conservation was regarded as a highly salient issue and received much support. We also noted that there was some confusion as to the alternative roles of the various State government planning authorities in wetland management. Of significance to this seminar, local government was nominated by slightly over a quarter of our respondents as a preferred source of information about wetland management.

In this paper, we describe attempts by twelve local government authorities to involve the public in wetlands planning and management. The commitment to public participation varied, apparently depending upon the strength of the local public comment. Most local governments have restricted public input to submissions on management plans or occasional public meetings. Those Councils experiencing some degree of concerted wetlands conservation action by their residents have moved to formalise relationships with active interest groups. This is usually in the form of on-going committees incorporating State and local government representatives as well as members of local community groups. These committees may provide a useful basis for on-going participation.

INTRODUCTION

This paper examines the role of Local Government in facilitating public input into wetlands management. We begin with a brief outline of how we gathered the evidence required for this paper. We then examine something of the theory behind the concept of public participation; and following a critical look at the positive and negative aspects of Local Government's potential role in this field, describe current practices and propose some recommendations for the future.

Initially, however, it is important to consider recent moves away from the traditionally ad hoc planning for recreational and environmental demands for water allocation and management, which has become increasingly unacceptable to the community. As the Western Australian Water Resources Council (WAWRC) has recently stated, "planning and implementation of future public water supply developments will be technically and socially complex". However, planning for and managing the expansion of demand for the private development of water resources against the need to preserve the environmental values of regional wetlands is likely to be even more complex. These issues will raise conflicts and pressures that the State agencies and the law are currently not equipped to handle" (WAWRC, 1988, p.5).

It is apparent that new management approaches are required and that more diverse information must be sought in order to improve and promote both the image and the effectiveness of current water and land planning. The WAWRC has realised the important role of grass roots involvement in the planning process and has noted that "the community now expects a more deliberate and public process to allow more explicitly for public input" (WAWRC, 1988, p.27).

METHODOLOGY

The information and social attitudinal data utilised in writing this paper came largely from a number of semi-structured interviews with relevant interest groups and the results of a community survey of attitudes towards wetlands and water allocation in the Jandakot Public Water Supply Area. We talked to active members of seven conservation groups with a major interest in wetlands; staff members from twelve City or Shire Councils with local wetlands; and six representatives from the four major State Government departments with an interest in this area (Conservation and Land Management (CALM), State Planning Commission (SPC), Environmental Protection Authority (EPA), Water Authority of Western Australia,) We examined each groups' attitudes towards the role of local government in promoting public participation in managing the wetlands.

WHY PARTICIPATION?

As indicated in the introduction, the Western Australian community is expecting higher degrees of involvement in decision making. Despite this increasing interest, however, there are large differences between the types of involvement offered by various government departments. There are also major contrasts in what is expected of the public involvementprocess by environmental planners. We briefly summarise the essential conceptual issues to provide background to the more specific issues of local government and wetlands. Fagence (1977) provides a comprehensive theoretical background to the public involvement process.

The reasons justifying public participation programmes can be classified into two quite general groupings (Thornley, 1977; Sarkissian and Perlgut, 1986):

1. Pragmatism - Participation as a means of arriving at decisions more efficiently; or
2. Ethics - Participation as a means of movement towards participatory democracy.

The former may be viewed as the more mechanistic and planner led. Decision-making efficiency is presumed to be achieved as a result of the exchange of information between the planning participants, education of the public, or generation of public commitment to a course of action.

The latter reason emphasises power and may be typified in a series of graduations from complete planner (or planning authority) to complete public control over decision-making (Arnstein, 1969). Participation is considered as a means for spreading power to provide public influence over decisions.

Balancing the competing demands of efficiency and ideal democracy is difficult. Different interest groups involved in a public participation programme may often see the compromises involved in arriving at this balance in a very different light. This sometimes may result in conflict between groups which can appear intractable due to differing expectations of the process.

Nonetheless, it is often the process of involvement which is important, rather than the eventual outcome. "An open planning process, providing easy access to the planners, can reassure people that they're being thought of" (Sandercock, 1975, p.7). That is, rather than having any overt impact on the outcome of the planning process itself, the public is often happy enough to know that they are at least being given the opportunity to contribute. This view of the public involvement process was demonstrated in the results of the social survey of Jandakot residents. It would seem from the Jandakot study of the study that the highest priority for public involvement in wetlands management is the creation of a process which is seen as fair and accessible to the community.

WHY SHOULD LOCAL GOVERNMENT PROMOTE PUBLIC INVOLVEMENT?

In our study of public attitudes towards groundwater and wetlands in the Jandakot area, we found a great deal of interest and knowledge about local wetlands issues. Whilst wetlands conservation was highly supported, we noted that there was confusion about the roles of the various State Government planning authorities in wetlands management. More relevant to this topic was the finding that over 80% of the 330 respondents to our survey indicated that they would appreciate the opportunity to have some involvement in wetlands decision making. Significant support was apparent for a number of methods of participation, from simply reading the local paper for information to becoming involved in community groups. Slightly over a quarter of the respondents to our survey nominated local government as a preferred source of information about wetlands management. This may be considered the first of a number of reasons for local government to seriously consider its role with regard to soliciting and using public involvement in the planning process. Other reasons include:

1. THE LOCALISED NATURE OF WETLANDS ISSUES

People feel most interested and competent in becoming involved with local or neighbourhood issues. Local authorities are generally the official body most aware of particular wetlands and neighbourhoods and are therefore the most logical body to deal with them. Also, conservation values tend to arise from interested local residents or ongoing community groups rather than from planning bodies. This puts local government in the ideal position of being close to and therefore reflective of the community concerns about wetlands. The fact that the process of public involvement is prescribed by statute for Environmental Review and Management Programmes (ERMP) and that Social Impact Assessments are an increasingly important component the ERMP procedure, makes it important for planning to include the expertise of local people.

2. AN ALTERNATIVE TO STATE GOVERNMENT ROLES

Concerned residents can deal personally with their own Councillors through local government and have easier access to Council staff than they generally do in dealing with large State Government departments, which can be quite daunting. Currently, under the terms of the State Conservation Strategy, the EPA (in conjunction with CALM, SPC and the Water Authority) has the role of looking after the environment. But all State Government departments have limited resources. Therefore the EPA are trying to sponsor greater community understanding in order to devolve responsibility to local authorities. From the residents' viewpoint, local Councils are also in the position to act as "watchdogs" over State planning authorities, presenting small interest groups' views.

3. WETLANDS MAY BE VESTED IN LOCAL GOVERNMENT

While the State planning authorities would like to manage all wetlands effectively, bodies such as CALM and SPC have limited resources for such activities. Thus, those wetlands under State Government control can tend to get more attention than do those vested in local councils. As well as advice from CALM, in their role as a conservation authority, local government could take a pro-active role and seek public involvement in managing wetlands vested in their authority.

4. GAINING LOCAL EXPERTISE AND LABOUR

By soliciting and encouraging the interest of local residents, Councils can obtain an important source of "free" labour for tasks which would ordinarily require many person hours of staff time (eg. the planning and allocation contributions of local advisory groups; active lupin or weed control; maintaining surveillance on local wetlands).

WHAT ARE THE PROBLEMS IN LOCAL GOVERNMENT INVOLVEMENT IN PUBLIC PARTICIPATION?

As well as highlighting the positive contributions which can be made by local government, several of our interviewees did identify some problems associated with local government involvement. These concerns are summarised below:

1. LACK OF EXPERTISE

The majority of local authorities we contacted acknowledged the fact that they lacked sufficient technical expertise to take complete control over the management of wetlands in their municipalities. And even those who have an Environmental Officer on staff recognised the need to seek advice on matters affecting the wetlands system as a whole. Also, some considered that Local Government tends to act more in respect to physical developments such as buildings, houses and public works, rather than for environmental concerns. The latter are seen by many outside local government as more the responsibility of the state conservation authorities, which are often considered to have more expertise and power. This, no doubt, is an accurate reflection of Local Government's historical role, but need not provide a model for the future role of Councils in environmental management.

2. VESTED INTERESTS

According to some of our respondents, Councillors, especially those who have limited personal environmental background or staff expertise available to them, may be unduly influenced by single-issue groups. These groups may tend to ignore the fragile nature of the wetlands system and the variety of factors which may need to be considered for their effective management. For example, sporting groups have in the past been a problem for wetlands regions, making demands for recreational reserves which require filling of wetlands. Ratepayers associations tend to have a marked degree of input to Councils due to their dual positions as financial contributors to the local government and as voters in Council elections. The inconvenience of midges

may lead some of these associations to have differing views about the desirability of insecticide use than those less personally affected by the problem and more interested in water quality problems. Finally, local residents may sometimes wish particular wetlands to be managed in a way which may not be compatible with the needs of those interested in regional planning issues. It may therefore be more difficult for a Local Government Councillor to appropriately balance local and regional interests than it would be for someone operating at state level.

3. INTERNAL CONFLICTS OF INTEREST

The advantages enjoyed by Local Government in providing a one-stop planning shop can also have disadvantages in organisational terms. For example, some problems may be envisaged as arising from conflict between local Parks and Gardens divisions (who are trying to maintain the environment and keep the people happy) and Engineering and Drainage sections (who could see the wetlands as drainage sumps), as well as Health inspectors (who are concerned with mosquito and midge breeding) and Environmental Officers (whose concern is for the well-being of natural regions).

4. TIME FRAME

Sensitive wetlands management requires consistency in policy and implementation over a long time period. To some it may seem more difficult for local authorities to maintain unwavering standards and commitment than for State government agencies. This may be due to the facilities of Local Government always being stretched, but might more obviously be because decision makers themselves change more frequently at Local Government level. The majority of Councillors (who are voluntary members of the community) tend to serve limited terms, and are not often involved with resource management decisions beyond consideration of more pressing development proposals.

5. PAST PERFORMANCE

Local Councils are seen by some to have tended to take action with regard to wetlands management only when there is pressure from their constituents. This seminar provides an indication that this attitude may be set to change.

CURRENT PRACTICE BY LOCAL GOVERNMENT

Respondents were asked what they thought of Local Government's current role in relation to wetlands. The replies from local government officers and members of active conservation groups indicated that they thought that Local Governments had not taken a prominent role. It was even made apparent that some environmental interests considered it more efficient and effective to deal directly with State Government departments and/or the relevant Minister rather than going through the local Council. Nonetheless, we found that a range of methods foreliciting public involvement is being used by local authorities. These include basic statutory ERMP requirements, occasional public meetings and open Council meetings, and formalised advisory committees. The most positive response from respondents came in the consideration of recently formulated wetlands advisory management committees, which have attempted to involve members of the public who are interested in the environment. Such committees provide advice to Council, who can then evaluate the options and make recommendations for planning in their region.

The inclusion of State Government representatives these committees is considered helpful in smoothing the passage of legislation at State level. The presence of personnel from State authorities also makes the community representatives aware that the recommendations of the Committee may not be implemented immediately due to the requisite bureaucratic process. Some current examples of such committees include:

. The Bassendean River Parks Committee

. The Karrinyup-Gwelup Reserves Advisory Committee

. The Star Swamp Advisory Committee

. The Wanneroo Lakes Management Committee

However, some negative comments were received about the committees. These comments were largely with regard to the size of some committees. Large committees tend to get bogged down in discussing issues which are too complex in some participants' eyes. Some participants prefer to keep discussions on specific problems with tangible solutions. It has also been suggested that such committees may find it difficult to change their membership over time as incumbents develop a "power base" within the group and the wider community.

In preparing this paper, we also examined practice from other states. We found that the precinct concept adopted by the North Sydney Council offers an advanced model of open government which may, in some adapted form, be utilised here. This system has been through a series of changes since its inception in 1972 through the work of Alderman (later Mayor) Ted Mack, and has been operating very effectively since 1980 in its present form. Initially, a series of public meetings was held in each neighbourhood locality to discuss the concept of public involvement in Council's decision-making processes and to canvass the draft objectives and procedures for public participation. The North Sydney Councilthen moved to define precinct boundaries in terms of both geographical constraints and similarity of resident interests. This initially resulted in a series of 25 Precincts, each of approximately 2 000 residents. These have since been modified to account for lack of local interest and other resource constraints to give a total of 21 currently-active Precincts.

The major objective of the Precinct System is to encourage total involvement of all residents in the making and influencing of all Council's decisions. A section of Council has been established to service the public involvement programme, with two full-time staff: a Precinct Co-Ordinator, and an Administrative Assistant. Each Precinct Committee also has a modest budget to assist in the distribution of notices of meetings and agenda, and general running costs.

However, whilst such a precinct concept tends to be responsive to public interests and to dissipate sectarian decision making, it cannot afford to become stagnant or institutionalised. Precincts must remain in touch with new developments and problems as they arise. For this reason, especially with the limited and more dispersed population within Western Australia, it may be better to consider the establishment of committees on the basis of interest (eg. environment or wetlands) rather than location as the main criterion. "Precincts" could, for example, be established in terms of

particular local lakes of significance or adjacent lakes for local authorities with prominent wetlands. Wetlands may be considered with other environmental issues where they are less salient. Such committee would require some local government support as is the case in the North Sydney situation. Nevertheless, the staffing requirements are modest.

State authorities could then draw on members from a variety of "Precinct" committees for public involvement in regional planning issues. These people should be well informed about their subject and able to participate confidently. Such a structure would avoid the need to establish new expertise for committees when each issue arises. From our interpretation of discussion with representatives from various authorities and interest groups, this would appear to be one effective means of incorporating and coordinating public involvement into the planning process for the relevant tiers of government.

CONCLUSIONS

The task of managing wetlands and associated aquifers requires integration of planning proposals in both the local and regional context. It also requires a relatively high level of technical expertise due to the complexity of interactions between land use and water resources. In our survey of Jandakot residents and regional interest groups around the Perth metropolitan area, we found a wide variety of opinions regarding what sort of organisational arrangements should be used to handle public involvement for water and wetlands management. Nevertheless, we make some recommendations in this section which we believe will be acceptable to the public and achievable by local government.

To improve public acceptance of decision making in a context of rising concern about water resources, ongoing public involvement needs to be incorporated into the planning process for future groundwater and wetlands developments at an early stage. Early involvement of the public in the planning process has been shown to facilitate acceptance of water resources planning both here and overseas (e.g. Syme, Macpherson and Fry, 1987). Given the major water allocation decisions facing planners in the South-West of Western Australia, it would therefore seem wise to incorporate public involvement in planning at this stage. The interest-based "precinct" system seems a sensible way to proceed and could readily be adapted from some of the current, more successful, local government innovations.

At the local level, people seem to prefer a system in which their interests are met by a local advisory committee. These groups could be facilitated by local government staff or consultants. The extent of public participation which could be fostered would be dependent on the demand from the community, as the commitment of limited local government resources could only be justified on the basis of the relative strength of local public comment. In addition to the local groups, it is also important to note that the wider community will need to be consulted from time to time on specific issues such as those which may have created general community concern. The local committee could, however, provide valuable input into the planning and conduct of wider programs. From the active management viewpoint, such committees could be involved in organising working groups for particular projects.

Finally, these groups could provide an informed community resource for State Government planning issues.

As we have already indicated, for these groups to run effectively a modicum of professional expertise supplied by Local Government would be necessary. As State Government may benefit at least modestly from such interest groups, some funding from this source for the facilitating staff could be considered appropriate.

For public involvement to succeed, it is also essential to continue and to develop educational programmes in the wider community. Wetlands and groundwater issues are complicated and planners would benefit from the wider understanding of the community. Local Government efforts in these areas can be informal, with local Councils having a role by acting as a clearing house for material from both State authorities and the public. The example of Wanneroo City Council may be used in this instance: they have erected signs on public wetlands advising of ERMP and EPA assessment of water levels, and have provided a contact number for comment by concerned people. There are also moves afoot to initiate school projects which would encourage children to "adopt a lake", thereby ensuring greater knowledge and long-term commitment to their care.

Finally, a specific point, it is important for interest groups to know who manages the wetlands they are concerned about so that they can directly address the appropriate body. It would be most useful for Local Government to act as the first point of contact in this respect, as they are the closest to resident interests and can refer queries onwards. However, the most recent list of wetlands vesting which we could was published in 1976 as an appendix to the System 6 report (Tingay and Tingay, 1976). With many changes occuring to the area and purposes of the wetlands reserves in the Perth to Bunbury region, and in the vesting of these reserves, it would be useful for a revision to be published for both local government and the interested public.

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A range of Council staff, and particularly those involved in day-to-day wetland management, should also be closely involved in plan preparation. This generally results in a better plan which can be readily and practically implemented by staff who have a "sense of ownership" for the document. Department of Conservation and Land Management (CALM) management plans are prepared on a project team basis. Each project team includes a planner, field staff and specialist officers (eg. wetlands research, landscape architects).

Other approaches are to employ consultants or recent graduates on a contract basis or liaise with universities and have management plans prepared as student projects.

One problem that may arise with plan preparation by consultants and students is that the plan is prepared as an isolated event. Neither is working on a day-to-day basis with other Council officers, and may not therefore be fully aware of Council policies, functions, resources and practices. The other problem is plan implementation. Unless there is very close Council involvement in plan preparation it is unlikely to be implemented.

WHAT SHOULD MANAGEMENT PLANS INCLUDE?

All management plans should include four parts:

Part 1 Information on the resources and values of the area.

Part 2 Management Objectives.

Part 3 Management Strategies.

Part 4 Implementation.

Preparing a management plan can be equated to baking a cake. The four parts listed above are the four quarters that together make a complete cake. However, the recipe used to make each quarter can be varied depending on the tastes of the Council involved (i.e. the needs of the particular wetland for which the management plan is being prepared). In the following discussion " lists of possible ingredients" are given for each of the four parts. The mix or recipe should be chosen for each management plan from the lists given. The lists are by no means complete; other ingredients may well enhance the flavour!

PART 1 RESOURCE INFORMATION

LOCATION

- where is it (Shire, adjacent roads)
- area (ha)
- reserved, purpose, vesting
- surrounding land use and its purpose

OTHER PLANNING CONSIDERATIONS

- Metropolitan Region Scheme
- Town Planning Scheme
- System 6
- State government involvement and interests
- Relevant Acts and legislation

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- Town Planning Scheme
- System 6
- State government involvement and interests
- Relevant Acts and legislation

HISTORY

. Aboriginal - Mythological significance, known sites
. European exploration and settlement

PAST USE

. Use of the wetland itself (Before and After Reservation)
. Use of catchment and impacts of surrounding land use (eg. bores, run off from roads)

PHYSICAL FEATURES

. Geomorphology
. Soils

HYDROLOGY

. Catchment
. Drainage (Including stormwater outlets)
. Groundwater
. Water levels
. Water quality - colour
  - temperature
  - pH
  - oxygen
  - nutrients
  - heavy metals
  - biological oxygen demand
  - turbidity

Factors affecting water quality

  - stormwater
  - fertilisers
  - groundwater
  - midge/mosquito larvacide
  - septic Tank leachate

VEGETATION

. Terrestrial
. Littoral
. Aquatic

FAUNA

. Invertebrates (includes midges And mosquitoes)
. Fish
. Birds - waterbirds, terrestrial
. Amphibians
. Reptiles
. Mammals

LANDSCAPE

FIRE

. History
. Environmental effects

PAST MANAGEMENT

- firebreaks
- weeds
- midges
- bulrushes
- signs
- rubbish
- recreation facilities

PART 2 MANAGEMENT OBJECTIVES

Defining management objectives sets the direction for the future. It also helps to clarify direction if any trade-offs between conservation and recreation, or conservation and local residents' demands for an unobscured view of a wetland, are needed. Three examples of general objectives follow.

Conservation of Highest Priority

Management objective: To protect and enhance the wetland as waterbird habitat for the present range of species.

Conservation and Recreation of Equal Importance

Management objective: To protect and enhance the wetland as waterbird habitat while at the same time meeting the recreational needs of the local community. Recreational use should not adversely affect the wetland's conservation values.

Recreation of Highest Priority

Management objective: To meet the recreational needs of the community, while ensuring that impacts on the wetland's natural environment are minimised.

Objectives should be developed in close consultation with Council staff and Councillors themselves. To be successful, objectives must reflect the Council's policies and broader community's attitudes, as well as recognising a Council's resources and functions.

PART 3 MANAGEMENT STRATEGIES

Management strategies should be developed for each management concern. In other wetland plans, strategies have been developed for:

Water quality
Water levels
Bulrushes
Mosquitoes and midges
Fire
Dieback
Weeds
Regeneration
Garden refuse and litter
Argentine ants
Domestic ducks and geese
Tortoises
Signs
Recreation
Monitoring
Community involvement

PART 4 IMPLEMENTATION

No plan can succeed unless it is implemented. Implementation can be made easier by tabulating all the strategies, who's responsible (staff member), costing, priority (low, medium, high) and frequency of the strategy (one-off or ongoing). The Benger Swamp Management Plan (CALM 1987, pp. 84-87) has an example of this tabulation process.

WHAT ARE THE STEPS INVOLVED IN PREPARING A MANAGEMENT PLAN?

Most management plans prepared these days are prepared as drafts for public comment. They are generally available for 2-3 months comment before being reviewed, based on comments received. The final plan is generally then endorsed by Council and implementation should follow. This approach has been used by the Cities of Melville, Stirling and South Perth.

Public involvement is a vitally important aspect of plan preparation. The public should be involved prior to preparation of the draft. This ensures all available information is used to formulate the plan and general better public acceptance of the plan itself.

Public involvement techniques which can be used both to prepare the draft and to obtain comments on the draft once it is released are numerous. Examples include workshops, letter box drops, questionnaires, distribution of leaflets, advisory committees, public meetings, panel discussions and so on. Choice of technique(s) will depend on the staff and resources available, level of community interest and concern, and the types of issues involved.

The length of time taken to prepare a management plan depends very much on the complexity of the problems, the size of the area, the amount of public participation and the experience of the planner.

For a staff member working full-time, a draft management plan (for an urban wetland) should not take more than 4-6 months. A further two months should be allowed for public comment, and then a further 4-6 weeks staff time preparing the final plan. About 1 month should be allowed for Council to consider the final plan. This gives a total of 8-9 months for a plan.

Plans can become out-of-date, so it is important that they have a limited term - say 5 or 10 years. This term should be written in an obvious place, such as the front page. There should also be the provision for revision as needed. Review may be necessary earlier than the 5 or 10 years if, for example, roading proposals make the plan unworkable.

CONCLUSION

In conclusion, to prepare a management plan you need to:

1. Decide who is going to prepare the plan.
2. Decide what the plan is going to include (determine the mix of ingredients for each of the four parts).
3. Go through the following steps:

    . produce a draft

    . make the draft available for public comment

    . produce a final plan for Council approval

The reference section at the end of this paper includes examples of wetland management plans produced over the last 4-5 years in Perth and adjacent areas.

Tables of Contents from several of these plans have also been included, for easy reference, as an Appendix to this paper.

AKNOWLEDGEMENTS

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APPENDIX: TABLES OF CONTENTS
FROM SELECTED MANAGEMENT PLANS

- BENGER SWAMP NATURE RESERVE
- WATERFORD FORESHORE RESERVE
- BOORAGOON LAKE

BENGER SWAMP NATURE RESERVE

MANAGEMENT PLAN

1987 - 1992

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Department of Conservation and Land Management
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MANAGEMENT PLAN NO. 7

CONTENTS

CITY OF SOUTH PERTH

Waterford Foreshore Reserve

Management Plan

RESERVE 37712 and LOT 389

KATE ORR

JANUARY 1987

CONTENTS :

CITY OF MELVILLE
ALMONDBURY ROAD ARDROSS 6153 WESTERN AUSTRALIA

BOORAGOON LAKE

MANAGEMENT PLAN

by Vanessa Smith

April 1986

C O N T E N T S

C O N T E N T S

C O N T E N T S